FIR/R171/Suppl

LIBRARY
APR 5 1976
FISH & WILDLIFE SERVICE

Supplement 1 to the Report of the eighth session of the

ADVISORY COMMITTEE ON MARINE RESOURCES RESEARCH

Sesimbra, Portugal, 8-12 September 1975

SELECTED WORKING PAPERS SUBMITTED TO THE EIGHTH SESSION OF ACMRR

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

SELECTED WORKING PAPERS SUBMITTED TO
THE EIGHTH SESSION OF ACMRR

SUPPLEMENT 1 TO THE REPORT OF THE EIGHTH SESSION OF THE ADVISORY COMMITTEE ON MARINE RESOURCES RESEARCH

Sesimbra, Portugal, 8-12 September 1975

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 1975

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The copyright in this book is vested in the Food and Agriculture Organization of the United Nations. The book may not be reproduced, in whole or in part, by any method or process, without written permission from the copyright holder. Applications for such permission, with a statement of the purpose and extent of the reproduction desired, should be addressed to the Director, Publications Division, Food and Agriculture Organization of the United Nations, Via delle Terme di Caracalla, 00100 Rome, Italy.

© FAO 1975

PREPARATION OF THIS REPORT

This document contains most of the Working Papers prepared for the Eighth Session of the Advisory Committee on Marine Resources Research, as edited and revised by the authors.

Distribution:

FAO Department of Fisheries
FAO Regional Fisheries Officers
ACMRR
Selector SM
Member Countries
UN Organizations members of ICSPRO
IOC
IABO
UNEP
Members of ACMRR Working Parties

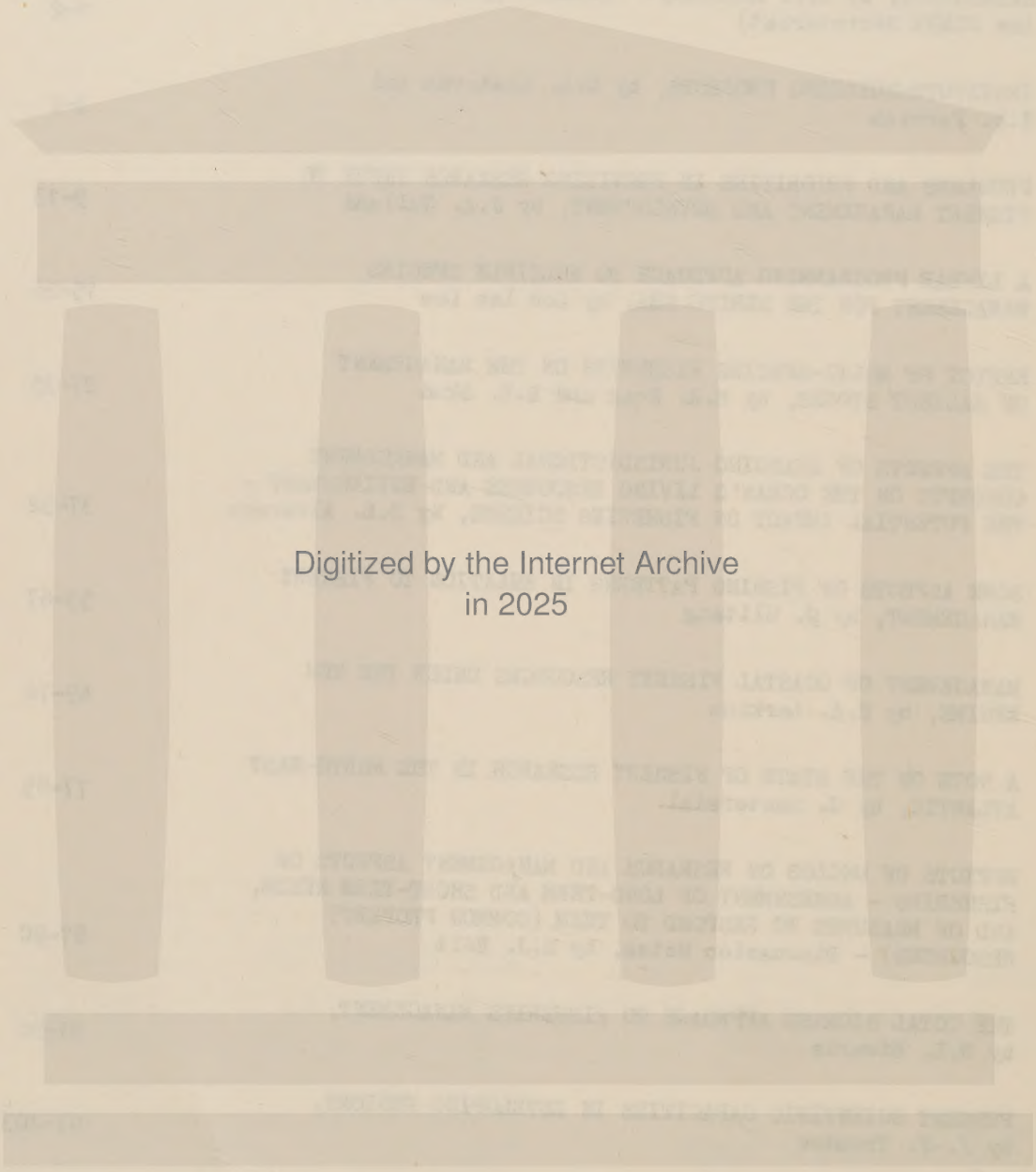
Bibliographic entry:

Advisory Committee on Marine Resources Research. Sesimbra, Portugal, 8-12 September 1975 (1975)
FAO Fish.Rep., (171)Suppl.1:136 p.
Selected working papers submitted to the Eighth Session of ACMRR. Supplement 1 to the Report of the Eighth Session of the .....

Marine resources. Resource development. Fishery institutions. Research projects. Education. International exchange. Fishery management. Mathematical models. Simulation. Fisheries sciences. Sea law. Overfishing. Fishery regulations. Multispecies fisheries. World Ocean.

CONTENTS

	Pages
THE EFFECT OF INCREASING MULTIPLE USE OF OCEAN SPACE AND RESOURCES ON WORLD FISHERY PRODUCTIVITY AND EXTRACTION, by R.P. McGreevy. SUMMARY (prepared by the ACMRR Secretariat)	1-2
INSTITUTE-BUILDING PROJECTS, by G.L. Kesteven and B.B. Parrish	3-7
PROBLEMS AND PRIORITIES IN PROVIDING RESEARCH INPUT TO FISHERY MANAGEMENT AND DEVELOPMENT, by J.A. Gulland	9-13
A LINEAR PROGRAMMING APPROACH TO MULTIPLE SPECIES MANAGEMENT FOR THE BERING SEA, by Loh Lee Low	15-26
EFFECT OF MULTI-SPECIES FISHERIES ON THE MANAGEMENT OF HALIBUT STOCKS, by S.H. Hoag and B.E. Skud	27-35
THE EFFECTS OF CHANGING JURISDICTIONAL AND MANAGEMENT CONCEPTS ON THE OCEAN'S LIVING RESOURCES AND ENVIRONMENT - THE POTENTIAL IMPACT ON FISHERIES SCIENCE, by D.L. Alverson	37-52
SOME ASPECTS OF FISHING PATTERNS IN RELATION TO FISHERY MANAGEMENT, by Ø. Ulltang	53-67
MANAGEMENT OF COASTAL FISHERY RESOURCES UNDER THE NEW REGIME, by H.A. Larkins	69-76
A NOTE ON THE STATE OF FISHERY RESEARCH IN THE NORTH-EAST ATLANTIC, by G. Saetersdal	77-85
EFFECTS OF UNCLOS ON RESEARCH AND MANAGEMENT ASPECTS OF FISHERIES - ASSESSMENT OF LONG-TERM AND SHORT-TERM NEEDS, AND OF MEASURES TO RESPOND TO THEM (COMMON PROPERTY RESOURCES) - Discussion Notes, by S.J. Holt	87-90
THE TOTAL BIOMASS APPROACH TO FISHERIES MANAGEMENT, by R.L. Edwards	91-96
PRESENT SCIENTIFIC CAPACITIES IN DEVELOPING REGIONS, by J.-P. Troadec	97-103
PROBLEMS IN MULTI-SPECIES FISHERIES, by J.A. Gulland	105-110
AID IN RESEARCH PROJECTS, by G.L. Kesteven	111-128
REVIEW OF THE PRESENT STATE OF ACTIVITIES OF THE ACMRR WORKING PARTIES AND JOINT SCOR/ACMRR WORKING GROUPS, by E.F. Akyüz	129-136



Digitized by the Internet Archive
in 2025

https://archive.org/details/fao-fisheries-and-aquaculture-report_1975-09_supplement

THE EFFECT OF INCREASING MULTIPLE USE OF OCEAN SPACE AND RESOURCES ON WORLD FISHERY PRODUCTIVITY AND EXTRACTION

by

R.P. McGreevy
Institute for Marine Studies
University of Washington
Seattle, Washington, U.S.A.

SUMMARY

(Prepared by the ACMRR Secretariat)

This report consists mainly of two major sections, reviewing the information according to the type of marine activity, and the areas, respectively.

In the first of these sections 11 different marine activities are identified that could have some impact on marine fish stocks, or on the fisheries exploiting them. These are:

Commercial Shipping
Naval Operations
Shoreline Development
Recreation
Submarine Cables
Marine Mining
Oil and Gas Developments
Offshore Installations
Direct Energy
Scientific Research
Waste Disposal

For each of these a general discussion is given of the nature of the activity, and of its possible impact on fisheries, followed by a statistical summary of the changes in and development of the activity.

The regional section has been divided according to the 15 major regions used by FAO for fishery statistics and similar purposes. Within each section charts and tables are given, showing the distribution of the major fisheries, the size of the catch, and the principal gears used. These are followed by similar charts giving the distribution and intensity of other, possibly competing, marine activities, particularly shipping, cables, shore and harbour development, and mineral, oil and gas prospection and extraction.

In the paper emphasis has been given on summarizing data from a number of different specialized fields in a form convenient for the non-specialist or a specialist in other fields. In this way it provides a readily available basis for the next stage of evaluating the degree of interaction between each of the activities considered and fisheries, and of the variation in this interaction in different areas and of likely trends.

Some preliminary examination has been made of the likely regional variations, giving a weighting to the degree of interaction in each region according to the importance of the regional fisheries, the magnitude of each non-fishery marine activity in the region, and the probable extent of the impact of each activity on fish stocks and fisheries. On this basis the most significant interaction is likely in the Northeast Atlantic and Northwest Pacific, and the least in the Southeast Atlantic and Southwest Pacific.

INSTITUTE-BUILDING PROJECTS

by

G.L. Kesteven
FAO Fishery Research and Development Project
Lima, Peru

and

B.B. Parrish
Marine Laboratory
Department of Agriculture and Fisheries of Scotland
Aberdeen, Scotland

CONTENTS

		Page
1.	INTRODUCTION	4
2.	THE EVOLUTION OF RESEARCH CLIMATE AS AN ELEMENT OF TECHNOLOGY TRANSFER	4
3.	A CONCEPT OF SISTER-INSTITUTIONS	5
4.	SOME OPERATIONAL CONSIDERATIONS	6

1. INTRODUCTION

Technology transfer is a major theme in discussions concerning development of the third world. Whilst the term signifies essentially an imparting of know-how for the conduct of industrial operations, in considerable measure it also embraces the cultivation of a capacity for scientific research and for the application of the results of research. A large part of the reason for the position of science in this process is obvious enough that the benefits that flow from the application of research results are the greater if the research has been directed expressly to the systems (ecotic, agricultural, industrial, etc.) in which the results are to be applied. There are, however, still other reasons for this position which, in some sense and in some circumstances, may carry the more weight; these relate to the conduct of research in and by a developing country itself: they concern the cultural, intellectual and other consequences to a country of having its own body of competent scientists, and its wish to be master of its own science, which it sees as part of its own freedom.

It is the purpose of this note to discuss briefly some neglect of these latter reasons and to describe a plan for institution-promotion projects which takes due account of those considerations.

2. THE EVOLUTION OF RESEARCH CLIMATE AS AN ELEMENT OF TECHNOLOGY TRANSFER

A development plan aimed at the creation of industry and infra-structure in a developing country so as to obtain economic benefits in the shortest possible time does not include a development of research capability, because the wish to obtain quick economic returns does not admit delay. If new scientific result is required in such a plan the research must be carried out by an institution of a developed country, or by staff of such an institution working in the country to be developed. This course can doubtless be justified in particular cases and we can leave such cases to one side, noting that they accomplish little or nothing of the deeper progress with which the other reasons for technology transfer are concerned.

However, a project expressly designed to achieve the deeper effects can have somewhat similar results. Thus, some scientists who accept assignments in institute-building projects see their assignments as opportunities to gain access to unique situations, to obtain field and laboratory data with little effort on their part, and to prepare scientific papers to advance their careers. Such persons may argue in justification of their action (a) that the scientific result as an end in itself justifies the means, or (b) that the achievement of the results more rapidly than would have been possible if local people had first to be trained could provide economic benefits from which the cost of training local scientists could be met, and (c) that in any case some of their science would rub off on those who had gathered data for them. Despite these arguments, ill-effects remain, and are often now described as intellectual colonialism. (We can neglect, for the purposes of this note, the ill-effects that flow from recruitment of experts interested only in travel, high salaries, etc.).

The foregoing are special cases. More frequently we are concerned with the case that an institute which has been enjoying assistance directed at enlarging the competence of the staff and the capability of the institute itself, remains at the end of the project with a staff competent in the application of various scientific techniques but unable, or unwilling to do research. Explanations for this condition may be found in social, political and other characteristics of the local situation, but to accept these without looking further would imply that the cultivation of an effective scientific attitude in such situations was impossible. We believe that at least some of the explanation of failure can be found in the aid technique itself: it is our preposition that the aid technique should be a version of those processes by which schools of research come into existence.

It must be obvious that an institute cannot be created simply by obtaining a building, equipping it and recruiting staff for it; nor will the institute be created even if special training is given to the staff and programmes are planned for them. An active institution is characterized by the intellectual climate that prevails within it, by the liveliness of criticism which is offered, accepted and acted upon, and by the effect of leadership in stimulating original thought and in developing a corporate discipline which orients the activities of individuals and groups towards the institution's principal objectives. In such a scientific climate self-promoting drives operate in fulfilment of individual ambitions and in the satisfaction of curiosity. The generation of ideas is further stimulated by the frequency of contact between persons and is promoted by the intellectual self-confidence which individuals acquire as they find that they can give and take criticism, and that they can hold their own in open discussion. As this happens the institute becomes capable of original contributions to knowledge and understanding. All these characteristics are promoted by the discipline and organization of the institution, and by the availability of technical and administrative services which are operating truly to promote and facilitate research. In addition, of course, all these conditions are contingent upon the continuity of employment, security, and the opportunity of advancement which can be offered in the institution; conditions which, of course, are dependent upon the economic conditions offered them.

3. A CONCEPT OF SISTER-INSTITUTIONS

Although an institution-promotion-project cannot hope, and should not attempt, to bring about all these conditions, its contributions should be designed in recognition of these fundamental characteristics of the processes by which a scientific attitude is cultivated. Many of these characteristics are of a nature that they cannot come readily at the site of the project but must be promoted through contact with other institutions. For this reason we propose a concept of sister-institutions. In this concept, the foreign staff of a project would all, or in the main, be drawn from one institution which would engage to share its competence and, where appropriate its facilities, with the project institution. Apart from the project director and perhaps one or two other key personnel who might hold long-term assignments in order to provide continuity, experts from the foreign institution would visit the project site on short-term assignments of two or three months; each expert might make two or three such visits in the course of the project, but between assignments he would maintain contact with his counterparts through correspondence and by the counterpart spending time in the expert's home institution. This plan suggests that there should be a systematic, well-planned movement of staff in both directions between the institutions. In this way, the local staff of the project would get the benefit of training, advice, and collaboration of experts at the site of the project, and would continue to receive that assistance in the experts' home institution where they would enter the scientific climate described above. A major advantage of such a scheme for the local institution would be the wide range of expertise available to it, which could be called upon at relatively short notice to deal with specific scientific and other problems arising in the course of its programme of work. In addition, the continuing contact and exchange between the local and foreign institute staffs would provide the basis for generating amongst the local staff the confidence and desire to enter into critical scientific discussion and appraisal of their work. The fact that steps would probably be taken on the part of both institutes to learn each other's language would be an important contributory factor.

In addition to the advantages accruing to the local institute, the sister-institute arrangement also would offer advantages to its foreign counterparts by providing a number of its staff with opportunities to broaden their research experience and extend their range of scientific interests. Further it would be less disrupting to the domestic programme of work of the foreign counterpart institution than to supply a smaller number of experts for substantially longer periods, as is the case with most aid programmes.

The arrangement also has this important advantage, that each expert would arrive, on his assignment, to a prepared niche, and each counterpart, as holder of a training fellowship, would not arrive among strangers but at an institute where he and his compatriots are already known. The effect of this advantage would intensify as the project continued.

We believe that projects designed and conducted in accordance with this concept would make a most effective contribution to institution promotion, would provide to research staff a more acceptable means of contributing to this work, and would be of mutual benefit to the two institutions.

4. SOME OPERATIONAL CONSIDERATIONS

Comparison of short-term and long-term assignments

Aid projects of the kind for which the sister-institute concept could be valid are usually designed with provision for recruitment of a number of experts for periods each of one, two or more years. Long-term assignments are necessary in certain cases, most especially in respect of Project Managers; they are preferred by some experts, and undoubtedly have their advantages; nevertheless, the following considerations should be kept in mind:

a) When a job description proves to be erroneous, signifying a set of activities not required, an expert nevertheless remains with the project, sometimes making himself useful, sometimes not.

b) The duties to be undertaken may be different from those for which the expert is trained, or which he is disposed to undertake (mistake in recruitment), with the same effects as for a).

c) Receiving institutes are sometimes slow in making preparations for experts, and the inclination to procrastination is stronger for long-term experts.

d) A long-term assignment generally means that the expert is accompanied by family, an arrangement which brings its own problems.

e) Many governments formally separate staff who accept long-term assignments, even for a single year, and this is a serious consideration even if re-employment is assured; superannuation problems are common; some assignments mean severance of ties with the home institute.

f) Of necessity a team of long-term experts is drawn from several institutes; ideological and cultural problems then emerge; integration of such a group is difficult to achieve because of the circumstances of such work; some experts separated from their home institute recognise no loyalty.

The sister-institute arrangement offers significant advantages to all who participate in it.

To the senior institute it means:

- less disruption of programmes, because the period of absence of each staff member is not so great that his current projects need be handed to someone else, or even abandoned; moreover, the work undertaken by each expert during his assignment is in the field of his current work and therefore he maintains contact with that work and may gain from applying his methods to different materials;

- a possibility of enlarging the range of research capability because salaries not paid to the staff during periods of project assignment could be applied in contracting new personnel;

- that benefits come from broadened contact, from stimulus to staff from 'change of scene' and opportunities to undertake comparative studies;

- a possibility of including an appraisal of each staff members contribution to the project in his service record.

To the expert himself the arrangement can be advantageous because of

- less disruption of personal affairs and professional programme;

- the probability that the time spent on the assignment will be more efficiently occupied since his visit can be timed to suit his work;

- his being able to know, through his colleagues who have already participated, or from a previous visit made by him, the nature of the situation to which he is going and of the problems with which he will be concerned;

- there being no break of continuity of service with his home institute.

To the junior institute the arrangement is advantageous in each respect that it offers advantages to the senior institute and the expert.

To an executing agency it offers advantages insofar as it reduces the problems of recruitment and briefing and relieves the agency of technical back-stopping.

Not a sub-contract

It is advisable to emphasize that this plan does not propose a kind of sub-contract, since the International Executing Agency (IEA) would:

- retain managerial and planning responsibility;
- be responsible for all employment contracts;
- appoint project manager;
- make all purchases;
- manage fellowships.

Selection of senior institute: Obviously the junior institute should have a major say in selection of the senior institute.

Project Manager: The IEA should appoint the project manager as its responsible representative; the PM must create continuity. The PM should take a major role in interpreting the wishes of the Government with respect to the research to be carried out, in identifying the areas of research in respect of which assistance from the senior institute could be effective, in timing the participation of the experts and travel by counterparts to the senior institute, in creating the 'niche' for each expert, and in ensuring a coordinated programme.

Management Committee: Formal arrangements should be made for regular meetings of the Directors of the two institutes with the PM and with the IEA's project officer and technical staff; if possible these should take place in the institutes themselves, alternating between one and the other; the meeting in the junior institute could be associated with an annual seminar and the UNDP tripartite review.

Formal Agreement: The plan implies a formal agreement between the IEA and the senior institute to establish:

a) that the one agrees to supply and the other to employ, experts within specified fields for a specified number of months;

b) a service fee to be received by the senior institute, the fee to be proportional to the cost of the experts, and to cover costs of training given in its laboratories and of facilities and services made available to the project, and if possible, to protect superannuation rights.

PROBLEMS AND PRIORITIES IN PROVIDING RESEARCH INPUT TO FISHERY MANAGEMENT AND DEVELOPMENT

by

J.A. Gulland
Fishery Resources and Environment Division
Department of Fisheries
FAO, Rome, Italy

CONTENTS

		Page
1.	INTRODUCTION	10
2.	RESEARCH PLANNING AND STRUCTURE	10
3.	TRAINING AND TRANSFER OF TECHNOLOGY	11
4.	REGIONAL AND INTERNATIONAL COLLABORATION	12
5.	DISCUSSION	13

1. INTRODUCTION

It is clear that several events (population pressure, over-fishing of several stocks, L.O.S., etc.) are causing developing countries to pay more attention to the fish resources adjacent to their coasts, both to increase their own national participation in their harvest, and to assume greater responsibility for their rational exploitation and management. Clearly, if these activities are to be successful, the decisions on fishery development, and the management measures must be based on adequate scientific advice. Equally clearly, most developing countries do not, at the present time, command enough scientific expertise within their own resources to provide this advice. In developing countries, as in developed, it seems that the fishery development is likely to give rise to problems which are increasing at a rate that exceeds the rate of growth of the scientific capacity to deal with them, i.e., despite improvements in the absolute level of research capacity, the level relative to the problems is falling.

In the longer-term, countries with major fishery interests will aim to build up their expertise to a level where they can be independent of outside advice, but for many others the size of their fishery cannot justify the large multi-disciplinary fishery research institute (such as those at Bergen, Seattle or Lowestoft) required to cover all aspects involved in preparing scientific advice. The size of a national fishery research institute depends on factors other than merely the actual or potential size of the national fishery and its problems, e.g., on the total national resources available and the priority for research, vis-à-vis, other uses of these resources, the size of the national scientific community, the interests in marine research as opposed to other research, etc. These are essentially national matters, outside the terms of reference of ACMRR, but within a general level of fishery research activities, advice on how these activities are planned and carried out so as to ensure the best development and management of fisheries is close to the heart of ACMRR's interests.

Advice on how research funds should be best used, so as to make good advice available, would be especially valuable when the national resources allocated to fishery research do not permit the establishment of a large research institute.

The overall problem of providing good scientific advice can be divided into three distinct aspects, as follows:

1) planning of research, and structure of research institutions, especially with limited budgets;

2) training, including transfer of science and technology;

3) regional and international collaboration to supplement national expertise.

Some of the points of each aspect that could usefully be discussed by ACMRR are outlined below.

2. RESEARCH PLANNING AND STRUCTURE

Given sufficient support, a large independent multi-disciplinary fisheries laboratory, with close links with administration and industry, is presumably the ultimate objective. Many countries cannot achieve this. What then should they aim at, at least in the medium term assuming that some form of outside assistance could be available to supplement national activities? Two activities in particular seem to require national activity - first the collection of basic data from the national fisheries and, at the other extreme, the provision of scientific advice to the decision maker in a form that he can understand, particularly as regards the impact on the national fishery.

Many of the intermediate steps - analysis of statistical data, stock assessment, traditional fishery biology to understand the behaviour and distribution of fish stocks, etc. - can be carried out without any particular national frame of reference. That is, provided the studies are made, it does not really matter to a country whether they are done within that country or elsewhere. This suggests that within any national programme very high priority needs to be given to data collection, and to the advisory function. Further one can suppose that the latter (and perhaps also the data collection) will be most effective if linked very closely to the office of the Director of Fisheries, or equivalent decision-taking post.

In brief, any fishery research unit, whatever its size, has to maintain links with (i) the general scientific community, (ii) the national fishery administration, and (iii) the fishing community. Failure to maintain any one of these links will, sooner or later, cause the work carried out to be of poor scientific calibre, misdirected or ineffective. A large institute can probably maintain these links without too much difficulty - though it is easy to think of examples, even in developed countries when this is not done, with sorry results - but how can they be best maintained in a smaller unit?

3. TRAINING AND TRANSFER OF TECHNOLOGY

Under this heading may be considered all the steps required to ensure that countries have national scientists in sufficient number and of sufficient quality, knowledgeable in the proper subjects to provide scientific advice adequate for the right decisions to be taken at the right time.

The call for more and better scientists is a refrain that runs through reports of ACMRR and other bodies for the last decade or more, but there is little sign of there being much improvement in the number or quality of scientists working on the major fishery problems. Why? Possible reasons are: 1) governments are not prepared to spend the money needed to attract the necessary quantity and quality of people, 2) the supply of potential fishery scientists coming from schools and universities is not adequate in number, or in fields of competence, 3) fishery institutes do not make proper use of the people available.

1) probably applies in many cases, especially where government institutions in developing countries do not offer the rewards open to scientists in other institutions in their home country or elsewhere. Have we spelt out clearly enough, and in ways in which governments (and especially treasuries) can understand, e.g., economic cost/benefit studies, the benefits of good fishery science?

2) (shortage of well-educated people) is certainly a problem in many small developing countries. Fishery interests can do little about this, except to recognize the situation, and adopt plans for research accordingly. Fishery people might consider whether any modification/addition to current educational curricula might be useful. For example, is it true that fishery institutes need recruits who have been trained in the basic subjects - mathematics and statistics, biology, chemistry, etc., rather than specialist training for fisheries which is best left until the man concerned has joined a fishery institute?

If this is true, what further training is needed - on-the-job training (i.e., often no training other than incidental osmosis) at the national institute, provision of manuals and similar material, short training courses of a few weeks in fishery science in general, or in specialized topics, or training in foreign institutes? Do any of these deserve particular high or low priority? Can anything be done to increase the efficiency of any technique? For example, at any one time there are some dozens of fishery scientists from developing countries at various institutes in developed countries, though rarely more than a very few at any one institute. Many do not receive formal instruction (lectures, study exercises, etc.), nor in general do the number of students at any one place at any one time justify this. However, even the training given is time-consuming for the staff of

the host institute. Are there more efficient ways of using the time and money, e.g., by combining individual training/fellowships into a series of more formal short courses attended by larger groups of people?

Training can also be considered in relation to the current needs and capabilities of the individual country. In another paper Kesteven and Parrish have described how a large fishery research institute might be built up in a developing country starting more or less from scratch. They distinguish successive, but overlapping, stages - first, when expatriate scientists do virtually all the scientific work, and are training national scientists at a fairly simple level, second when outside expertise is used only to supplement national scientific work, and to give more advanced training, and a final stage in which outside assistance is generally restricted to advice on certain specific topics for which national expertise does not exist. At any one time there will probably be some developing countries in each of these phases, and training may have to be matched accordingly. Does this mean, for example, that a slightly different training in basic fishery biology should be given to the young biologist from country A, who will go back home to be one of the only two people doing fishery research there (and may well soon go on to an administrative post), compared with one from B, who may go to a large active research laboratory? Or will both benefit from say a general course on the role of fishery research in improving national fisheries, and on the main lines of such research?

Another important aspect of transfer of science and technology is information. The volume of publications (which should be considered in a fairly wide sense) which are of actual or potential interest to fisheries is enormous (ASFA contains more than 1000 entries a month). Information retrieval systems, including those being used by FAO, are steadily becoming more sophisticated, but on the whole the advanced systems are most easily used by scientists in developed countries with easy access to good libraries, etc. They may therefore help to widen the gap between more and less scientifically advanced countries. What improvements can be made, particularly by FAO, to improve the situation? Assistance is especially needed by scientists working in a small fishery administration with only one or two scientists in all, who have little prospect of being directly supported by librarians or similar people, and by those in rather larger institutions currently without such staff and facilities, but for which the establishment of such facilities on an appropriate level is needed. Relevant questions which need to be answered by an information system are: What research is being carried out in the region by other countries and institutions (probably fairly easy to handle by mechanical retrieval using an area-based index)? What research carried out elsewhere is relevant to local studies, e.g., a new method of using length-data to estimate mortality rates (much harder to deal with, since it requires a subjective evaluation of the usefulness and relevance of publications)? How does the scientist actually get hold of publications (especially in the less well-distributed journals) which come to his notice? Possible actions include production of annual bibliographies for FAO regional bodies, and an annual listing of the 100 (10?, 1000?) publications of general relevance and importance.

4. REGIONAL AND INTERNATIONAL COLLABORATION

No country can rely wholly on its own capacity in fishery research (or indeed any other research). As its capacity grows, so, in general, do the range and complexity of problems that need to be looked at. Some international collaboration should be a permanent feature of any fishery research programme, whatever the state of development of the country concerned. However, there are differences in the nature of the exchanges involved. For regions in which most countries have poorly developed fishery research, the main international exchange is likely to be a flow of information and ideas from outside, but as local capacities increase inter-change within the region will become more important, and there will be a more even balance in the flow between the region and other parts of the world.

A major question is that of the mechanics required to make these inter-changes effective. Obviously some sort of regional body is needed, but what subjects should be included? Should fishery research (which always needs a regional approach) be kept separate from any regional management function on the ICES/NEAFC model? Do other aspects of marine research need to be formally included, or can we rely on the ability of capable scientists to be aware of most relevant activities in related fields, with resulting savings in bureaucratic activities, meetings, etc? Most important, what should be the role of the secretariat? Do bodies with part or most of the membership consisting of countries with currently little expertise require a greater scientific input from the staff of the regional body? How far can or should the regional body and its secretariat go in making sure that the scientific results are made available to the right people in each country in a form they can use? This is important because one argument against full "freedom of scientific research" is that however fully, freely and equally the results are distributed, the ability to interpret and use the results (unless special assistance is given) is heavily biased in favour of the larger advanced countries.

5. DISCUSSION

This paper attempts to outline some of the questions that need to be answered in assessing needs and measures to respond to them, rather than to produce the answers. Thus it is intended to provoke rather than pre-empt discussion in ACMRR. Some of the major questions are as follows:

Research structure

What sort of arrangements for fishery research are needed for countries with different magnitudes of resources (immediate and long-term) available for this research?

What arrangements are needed to ensure a) basic data collection, and b) provision of advice to decision makers, especially in the absence of a large independent fishery research institute?

Are these [(a) and (b)] the correct priorities? Should others be added?

Supply of scientists

Do we need to make a more persuasive case for "more and better scientists", and if so, how do we do it?

Is the present mix of fellowships, training courses, manuals, the right one, and if not, how should it be changed?

What is needed to improve the individual elements? Do scientists in small developing countries have an effective access to the world scientific literature? If not, how can it be improved?

Regional bodies

Does the role of regional bodies and of their secretariats differ according to membership?

How active should the secretariat be in carrying out some aspects of research, and in interpreting the results to decision makers?

A LINEAR PROGRAMMING APPROACH TO MULTIPLE SPECIES MANAGEMENT FOR THE BERING SEA

by

Loh Lee Low
Northwest Fisheries Center
National Marine Fisheries Service
Seattle, Washington 98112
U.S.A.

CONTENTS

		Page
1.	INTRODUCTION	16
2.	PRESENT MANAGEMENT AND RESEARCH	16
3.	MODELLING AS RESEARCH AND MANAGEMENT TOOLS	17
	3.1 Three simulation models	17
	3.2 Present data base	20
	3.3 Status of stock analysis	20
	3.4 INPFC and bilateral discussions	21
4.	A MANAGEMENT MODEL	21
	4.1 Purpose	21
	4.2 The linear programming approach	21
	4.3 Notations	22
	4.4 Input information	22
	4.5 General formulation	24
	4.6 Linear programme solution	25
5.	CONCLUSION	25
6.	REFERENCES	26

1. INTRODUCTION

The development of large-scale, highly effective distant water fisheries in the eastern Bering Sea during the past two decades has made that region a major world fishing area. The amount of fish caught by the multi-national and multiple species fishery - pollock, yellowfin sole, Pacific cod, and others - has increased very rapidly and since 1970 the total has exceeded 1.5 million metric tons (mt) annually. During the expansion of the fishery, the catch of some species has dropped drastically, gear use and species preference conflicts have arisen, and the need for rational management of the complex of fishery resources has become more and more obvious.

This paper discusses some general plans of digital modelling for examining implications of managing the major groundfish and crustacean resources under current exploitation. Because the objectives of management are many and a wide variety of regulatory measures are possible, it is therefore not the intent of this paper to suggest the type of fishery regulation necessary. The goal is to formulate a systematic approach to management of the resource and to gain insight to management strategies - given any set of regulatory objectives - by techniques, such as the linear programming technique.

2. PRESENT MANAGEMENT AND RESEARCH

Around October and November of each year, the International North Pacific Fisheries Commission (INPFC) meets to discuss the status of fisheries and stocks in the northeastern Pacific Ocean, including the eastern Bering Sea. Each year the latest fisheries statistics and associated biological data are exchanged among the INPFC member nations of the United States, Canada, and Japan. These data are then distributed to various fishery agencies of the member nations, analyzed, and the results discussed by the INPFC the following year. Except for Pacific halibut, the Commission has made no recommendations for conservation measures for the groundfish resources of the eastern Bering Sea and northeastern Pacific Ocean.

Such matters are taken up by Japan and the United States during bilateral meetings every two years. Information on the fisheries and the stocks is used in bilateral negotiations on catch quotas, closed areas, closed seasons, and other conservation arrangements. Of late, some agreement has been taken to reduce catches and control fishing effort on certain groundfish species.

The effectiveness of the conservation measures agreed upon by the three parties of INPFC with respect to halibut or by Japan and the United States with respect to certain groundfish species hinges to a considerable extent on management of fisheries conducted by other nations, particularly the Soviet Union, which conducts the second largest fishery in the Bering Sea. Thus, each year, scientists of the United States and the Soviet Union meet to exchange fisheries and scientific data and to review stock conditions. Later, representatives of the two nations hold fisheries negotiations.

Similar bilateral meetings are held with the Republic of Korea and, lately, the People's Republic of Poland when once again the rigorous exercise of reviewing stock conditions and negotiating conservation measures is carried out.

The present management arrangements, therefore, have been made as fisheries problems arise. Kasahara and Burke (1973) noted many unsatisfactory features regarding the present ad hoc case-by-case resolution of fisheries problems in the North Pacific. The present institutional arrangements lack a comprehensive systematic approach and problems arise because of questionable role and authority of managerial powers. It is desirable that the deficiencies in the existing institutions and their jurisdiction be clarified soon, either through international law (Law of the Sea conferences) or through unilateral actions by the United States. If the Law of the Sea conferences fail to come to an agreement on fisheries jurisdiction, the United States Congress may choose to resolve the issue through unilateral extension of its fishery zone. If this action is taken, there will undoubtedly still be multi-national fisheries in the eastern Bering Sea and a need for formulating a systematic approach to manage the resources by agency or agencies.

To a certain extent any new management strategy will still maintain the present research procedures that lead to management negotiations on a bilateral basis. Typically, the stages involved follow the steps given in Figure 1. Beginning with data collected or supplied by other nations, a rigorous evaluation of stock status follows. As to Bering Sea groundfishes, the main source of data is the Fisheries Agency of Japan. Those data that have been particularly useful in the past for stock status evaluations are catch-effort statistics by species (about 13, excluding crab) in 1° longitude by $\frac{1}{2}$° latitude grids. The interpretation of these types of fishery statistics has always been a problem (Low, 1975). Each year, Japan and the United States present ways and means of interpreting the data. Unfortunately, there is no completely satisfactory way.

Most of the data analysis has proceeded on a single species basis and, supplemented by biological (mainly length-weight-age) data, recommendations are made as to what ought to be optimum or maximum sustainable yield.

From then on, discussions on the analyses and results are held in bilateral discussions and within INPFC. Up to this point, however, and even if agreement is reached on catch quota and closed areas, there is no formal "tool" to determine open and closed areas so that catch quotas could be met on an optimal basis. Such a tool can be developed since the state of the knowledge on groundfishes exploited in the Bering Sea, though not complete, is sufficient to formulate rational management schemes. Moreover, the state of the art in computer modelling permits examination of ways and means to optimize exploitation strategies. With these points in mind three models have been considered.

3. MODELLING AS RESEARCH AND MANAGEMENT TOOLS

3.1 Three simulation models

The Northwest Fisheries Center of the United States National Marine Fisheries Service devised plans for an extensive ecosystem modelling of the Bering Sea. The effort is to be long-term and designed to understand the important mechanisms involved in multiple species dynamics of the Bering Sea. Even more ambitious are plans to study the Processes and Resources of the Eastern Bering Sea Shelf (PROBES). Such a PROBES study is planned jointly by the University of Alaska, University of Washington, and the National Marine Fisheries Service (Kelley and Hood, 1974). The study calls for field experimentation to be followed by a modelling effort to relate oceanography to lower trophic level production.

This modelling effort will then be interfaced to the upper trophic level ecosystem modelling involving man, marine mammals, fishes, crabs, and birds. The entire effort in ecosystem modelling is classified as Model 1 (Figure 2). Model 1 is therefore, at best, one which may help us understand intricate complications in the ecosystem. Though useful, it may not, on the other hand, be appropriate to make management decisions. The whole problem is not necessarily in the art of modelling itself but in the lack of knowledge on ecosystem interactions.

Ecosystem interactions and dynamics are complex and probably change in such a way that we may never understand them. It is surmised, however, that the exercise will be valuable and hence will be initiated as soon as possible so that we may continually upgrade and update the technique of aquatic ecosystem modelling.

A second useful model (Model 2, Figure 2) is one which may be used to simulate the dynamics of demersal populations of commercial importance. Basically, there are two types of mathematical models used extensively in fishery dynamics: the dynamic-pool model and the surplus-production model. Dynamic-pool models, such as those of Beverton and Holt (1957) and Walters (1969), attempt to identify the various basic parameters of an exploited population, i.e. recruitment, growth, and natural mortality and to combine them in an analytical model. On the other hand, surplus-production models, such as those of Schaefer (1954), Pella and Tomlinson (1969) and Fox (1970) consider the resultant effect of production only as a function of population size and fishing effort.

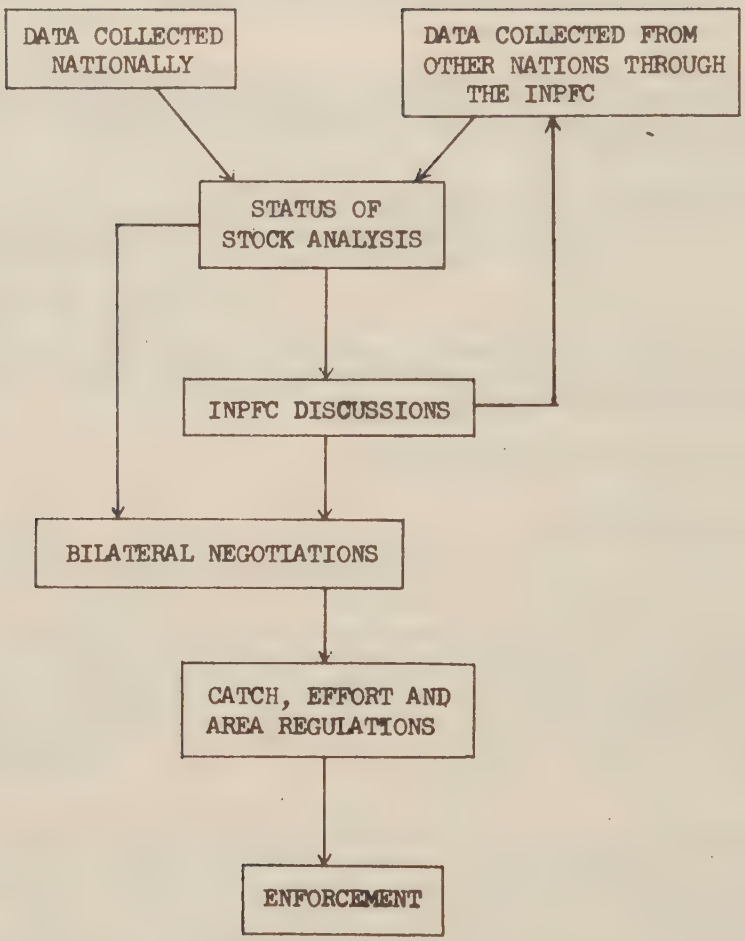


Figure 1. Current procedures and research for managing fishery resources of the Bering Sea

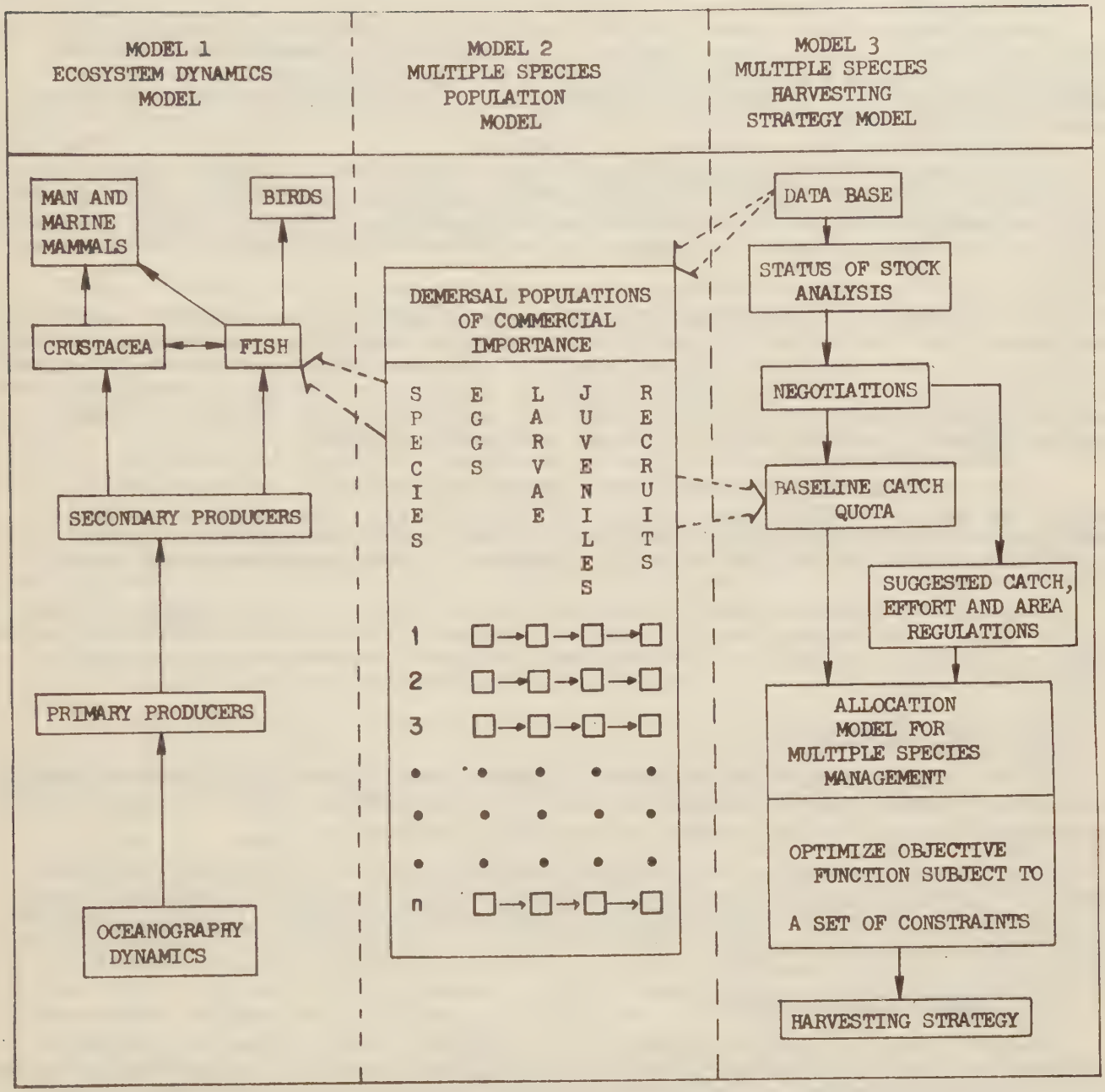


Figure 2. Three proposed models for studying and managing fishery resources of the Bering Sea

To a certain extent, catch-effort analysis of groundfish in the Bering Sea on a single species basis has been going on for many years. The relations of fish production to fishing effort and stock structure have been analyzed before by either or both of the two fundamental models mentioned.

Model 2, however, will probably adopt principles of dynamic-pool and surplus-production models when needed and use digital simulation approaches. It is possible to examine the complex multiple species system of the Bering Sea. Difference equations with feedback mechanisms, both from a deterministic and stochastic standpoint, may be formulated to represent actual conditions.

As with Model 1, the usefulness of Model 2 will be limited, due to lack of information on the basic biology and dynamics of exploited fish populations. Undeniably, however, the exercises need to be started and there are some data available to do so. In time, we will be closer to understanding how the demersal multi-species complex would react to selective fishing.

Other than the two models mentioned and on a more immediate basis, there is need for a management model - one of allocation which will optimize certain objective functions subject to certain sets of constraints. The end result of this Model 3 (Figure 2) is an allocation of catch by species by area and time which are currently derived through informal procedures and through experience. It is proposed that this model be the first addition or change to current management procedures and its concept is discussed further.

Model 3 will rely heavily on the latest data in the data base. It is not meant to measure the effects of fishing but instead, is to be used to allocate fishery resources according to what stock evaluations (Figure 2) indicate. Once catch quotas are agreed upon, the allocation model may be used to play a large part in developing a management scheme.

Therefore the allocation model will get input data from (1) the continuing data base, (2) status of stock analysis, and (3) optimum or maximum yield defined and agreed upon after INPFC or bilateral negotiations. Before getting into the fundamentals of the proposed model, the necessary three steps involved will be discussed in more detail.

3.2 Present data base

It is not appropriate in this paper to suggest a better data collection system for the Bering Sea. Instead, as much information would be drawn from the existing Bering Sea data base which consists mainly of commercial catch-effort information.

More and more quality data will continue to be collected - not only that of catch-effort - but also biological information, which may be used to determine structural change in exploited populations. These types of information will enter into stock appraisals which will be continually refined.

3.3 Status of stock analysis

Status of stock analysis has always been an important task to Bering Sea bottomfish studies. Both the U.S. and Japan have conducted extensive research to understand the status of the fisheries. However, as in all stock analysis with commercial catch-effort data, these analyses are subject to many interpretations and much critical review.

There are major problems in the interpretation of effort data (Low, 1975; Chikuni, 1975), single species versus multi-species approach, and the transient nature of population stability. Unfortunately, multi-species interactions are difficult to understand though the ecosystem modelling concepts of the Northwest Fisheries Center will be valuable, in time to come, in understanding processes of population change in the Bering Sea. Meantime, management implications suggested through present analytical techniques do not seem unreasonable.

With new data added every year, the results can be refined annually. Therefore, the entire status of stock analytical exercise will be continued for many years to come. Some analytical procedures will be modified and improved from time to time, but the exercise must go on to provide information for INPFC, bilateral meetings, or internal organizational discussions.

3.4 INPFC and bilateral discussions

Until agreement is reached at the International Law of the Sea Conference or unilateral action is taken by the United States to extend her fishery economic zone, multi-national negotiations on Bering Sea groundfish management will continue. It is agreed here that there are more efficient organizational structures and machinery for management than the current ad hoc arrangements. However, a systematic plan for management by the United States may not be far off; especially in the light of changing jurisdiction and concept as regards to the so-called "exclusive economic zone".

Such a plan may alter or abolish the present institutional arrangements of international fisheries. Fisheries problems may then be solved consistent with sound biological considerations and policies. For example, the concept of "optimum utilization" of the total biomass may be more consistently defined.

Once optimum utilization is defined, a detailed management scheme will have to be devised with considerations for criteria like: (1) status of the stocks, (2) value of the fishery, (3) gains to be expected from implementation of a sound management scheme, (4) national priorities, (5) cost of management, and (6) ease of enforcement.

It is at this point that an allocation model becomes of great help in evaluating alternative arrangement schemes. Given some assumed catch quota of certain species subject to certain conditions, the model may then be used to devise and evaluate harvesting strategies.

4. A MANAGEMENT MODEL

4.1 Purpose

The main purpose of the management model is to determine when and how much fish should be allowed to be harvested in specific areas so that management objectives are satisfied. This purpose quickly brings to mind some sort of an allocation model or an optimization "game" by multiple fishing fleets with multiple goals on multiple resources.

For example, through status of stock analysis and international agreement, baseline catch quota by species for the Bering Sea may be set as follows: Alaska pollock (1 million mt), yellowfin sole (75 000 mt), Pacific halibut (500 mt), Pacific ocean perch (40 000 mt), sablefish (6 000 mt), Pacific cod (60 000 mt), all other flounders combined (35 000 mt), incidental catch of snow (Tanner) crab in groundfishery (100 000 crabs), and incidental catch of king crab in groundfishery (30 000 crabs). The management must now determine which area and when to close to fishing bearing in mind present harvesting capability, feasibility of harvesting strategy, and fulfilment of catch quota - to name only a few constraints.

If so desired, the model may be further extended or the objective function changed to economic values (instead of catch weight) so that economic gains may be maximized.

4.2 The linear programming approach

For simplicity, let us use linear programming (LP) concepts in an allocation model. Alternatively, a competitive games approach using optimal control theory may also be used. The LP approach is chosen meantime because its concept is simple, it is widely accepted in the commercial world, and has well formulated algorithm including that for sensitivity analyses. Besides, the "controls" on fishery populations are not understood beyond linear terms.

Let us also, for simplicity, make some assumptions about the objectives and constraints of management and proceed with formulating an LP problem. Besides input data on baseline catch quotas, constraints of management goals must also be formulated. Above all, the history of the fishery - especially recent patterns of harvesting capability - must be properly formulated as input data.

4.3 Notations

Let C_{satg} be the catch in metric tons of species s in area a in time period t by gear-vessel class type g

u_{satg} be the expected catch per unit of fishing effort by species, by area, by time and by gear-vessel type

f_{atg} be the nominal standard unit of fishing effort by area, by time and by gear-vessel class type

It follows that:

$$C_{satg} = u_{satg} * f_{atg} \quad \text{for all s, a, t, g}$$

The data base for the Bering Sea shows that:

s = 1.....S and S = 15 species,

a = 1.....A and A is about 850 1^{o} longitude by $\frac{1}{2}^{o}$ latitude blocks,

t = 1.....T and T = 12 months,

g = 1.....G and G is about 25 important gear-vessel class categories.

Realistically, it is not practical to follow a harvesting strategy involving 850 statistical areas. Instead, areal division may have to be reduced (perhaps to 10 logical blocks as distinct biological niches), which may also be easily enforced if any area was declared closed to fishing.

4.4 Input information

Initially, as input information, we need a set of desired catch quota data. Assume that the quota are:

$$\sum_{g=1}^{G} \sum_{t=1}^{T} \sum_{a=1}^{A} C_{1atg} = \text{1 million mt of species 1 or pollock}$$

$$\sum_{g=1}^{G} \sum_{t=1}^{T} \sum_{a=1}^{A} C_{2atg} = \text{75 000 mt of species 2 or yellowfin sole}$$

$$\vdots$$

$$\sum_{g=1}^{G} \sum_{t=1}^{T} \sum_{a=1}^{A} C_{15atg} = \text{weight of 14 million species 15 or tanner crabs}$$

In general, and by notation, the catch constraint equations become

$$\sum_{g} \sum_{t} \sum_{a} c_{satg} \leq B_s \quad \text{for all s}$$

$$c_{satg} \geq 0 \quad \text{for all s, a, t, g}$$

where B_s are catch quota constants.

We also need to know the following information:

(1) an up-to-date inventory of fishing vessels by vessel size and fishing gear,

(2) vessel affiliation with mothership fleets in the case of vessels that are dependent on larger vessels,

(3) estimates of maximum fishing effort capability in each unit area and time period that may be expended by each of the n^{th} gear-vessel class types

(4) estimates of u_{satg} from the existing data base of commercial catch-effort statistics and groundfish trawl surveys.

Item 4, the estimation of u_{satg} will be a complicated task. In fact, the validity of the allocation model will rely heavily on these estimates because expected values of fish catch are computed by

$$E(c_{satg}) = u_{satg} * f_{atg}$$

Next, and according to the goals of management, we will formulate a set of conditions that has to be met in the groundfishery. For example:

(1) it may be desirable to limit the incidental catches of Pacific halibut, tanner crab and king crab by trawl vessels to certain amounts,

(2) it may also be desirable that certain areas be exclusively closed to trawling so as to create a pot-fishing sanctuary area, and

(3) that conditions should also be set so that the opening and closing of fishing areas will be properly timed to allow for travel time and other pertinent factors.

At this time we do not wish to elaborate on a complete set of constraints except to present the general concept. All these management goals must be translated to algebra and formulated into constraints.

For example, the fishing effort by boats of gear-vessel class category g=1 in area a=3 in month t=5 is greater than 500 hours trawling but less than 1 000 hours trawling. Therefore:

$$500 < f_{351} < 1\,000$$

In general we may formulate effort constaints as

$$f_{atg}^{(min)} \leq f_{atg} \leq f_{atg}^{(max)}$$

$$f_{atg} \geq 0 \text{ for all a, t, g}$$

In the case of different gear-vessel types fishing in mothership fleets, a single gear-vessel classification may be given to denote the standardized fishing effort of each fleet. Such a clustering of fishing effort may be unsatisfactory and we may have to resort back to individual gear-vessel type categories. Then some formulation will have to be made to identify and aggregate the fishing effort of vessels in the same fleet.

The relation between catch and effort will also have to be included. Therefore we also need estimates of u_{satg}, for all s, a, t, and g.

4.5 General formulation

Using the notations and assumptions presented, we wish to maximize an objective function:

$$z = \sum_g \sum_t \sum_a \sum_s c_{satg}$$

Subject to:

catch quota constraints

$$\sum_g \sum_t \sum_a c_{satg} \leq B_s \text{ for all } s$$

catch fishing effort constraints

$$\left(\frac{1}{u_{satg}} * c_{satg}\right) \leq f_{atg}^{(max)} \text{ for all } a, t, g$$

$$\left(\frac{1}{u_{satg}} * c_{satg}\right) \geq f_{atg}^{(min)} \text{ for all } a, t, g$$

$$c_{satg} \geq 0 \text{ for all } s, a, t, g$$

It may even be better to formulate the LP problem with effort as the decision variable since effort values can directly be associated with cost functions and the species dimension in the decision variable can also be eliminated. Therefore we may wish to maximize an objective function

$$z = \sum_g \sum_t \sum_a \sum_s (f_{atg} * u_{satg})$$

subject to:

catch quota constraints

$$\sum_g \sum_t \sum_a (f_{atg} * u_{satg}) \leq B_s \text{ for all } s$$

fishing effort constraints

$$f_{atg} \geq f_{atg}^{(min)} \text{ for all } a, t, g$$

$$f_{atg} \leq f_{atg}^{(max)} \text{ for all } a, t, g$$

$$f_{atg} \geq 0 \text{ for all } a, t, g$$

So far the LP problem only considers catch weight. It can now be modified to consider economic values, such as price per ton by species, by utility, travelling time cost, fishing cost and other pertinent economic conditions. Let

P_{sm} = price per ton of species s by meat utility m

t_g = travelling expense per unit time by gear-vessel class type g

e_g = fishing expense per unit time by gear-vessel class type g

⋮

etc.

The new LP formulation may now be transformed into:

$$\text{maximize } Z = \sum_{g} \sum_{t} \sum_{a} \sum_{s} (f_{atg} * u_{satg} * P_{sm}) -$$

$$\sum_{g} \sum_{t} \sum_{a} (f_{atg} * e_{g}) - \text{travelling expenses}$$

$$- \text{other expenses}$$

subject to constraints on:

- catch
- fishing effort
- fishing cost
- travelling cost
- .
- .
- .
- etc.

In these days of high labour and fuel cost, such economic objectives must be of prime consideration.

4.6 Linear programme solution

The LP problem has not yet been properly formulated. What has been presented merely explores the concept of applying LP in multi-species management for the Bering Sea. To quote from Rothschild and Balsiger (1971):

> "...once the objective function and the constraints have been formulated, then optimization of the objective functions, given the constraints, is a standard procedure outlined in some detail in the literature, and, with a computer facility, is a relatively simple task."

It may be added, however, that the computer core memory may have to be very large to realistically handle multi-species groundfish management problems. The CM requirement is primarily related to the number of constraint equations and the number of variables. With proper formulation, perhaps with that of the dual, the LP solution may be possible.

More directly, there are a few computer programmes and a number of large computer facilities that we have access to for solving our LP problems. The Multiple Purpose Optimization System (MPOS) by Cohen and Stein (1974) will solve LP problems using regular simplex, revised simplex, dual simplex, or minit (variant of the primal-dual methods) procedures.

5. CONCLUSION

This paper is not complete in the sense of proven final solution to multi-species management for the Bering Sea. It is meant to stimulate comments and thoughts on the application of operations research, with LP as an example, to evaluate multi-species management problems.

The LP approach of resource allocation should be of immediate help for formulating management schemes. Moreover, the concept is applicable universally for groundfish as well as for other fishery systems. Each year, with new data coming in, we can re-evaluate the implications of our previous management scheme and iteratively improve our management capabilities.

6. REFERENCES

Beverton, R.J.H. and S.J. Holt, On the dynamics of exploited fish populations. Fish. Invest., Lond.(2), (19):533 p.
1957

Chikuni, S., Problems in monitoring abundance in the multi-species and multi-gear groundfish fisheries in the Bering Sea. Paper prepared for presentation to the Advisory Committee on Marine Resources Research Working Group on Fishing Effort and Monitoring of Fish Stock Abundance, 15-20 December 1975. Rome, FAO, 20 p.
1975

Cohen, C. and J. Stein, Multiple purpose optimization system user's guide, Version 1.0. Evaston, Illinois, Vogelback Computing Center, Northwestern University. 108 p. (Processed)
1974

Fox, W.W. Jr., An exponential surplus-yield model for optimizing exploited fish populations. Trans.Am.Fish.Soc., 99(1):80-8
1970

Kasahara, H. and W. Burke, North Pacific fisheries management. Washington, D.C. Resources of the Future, Inc. 91 p.
1974

Kelley, E.J. and D.W. Hood (Eds.), PROBES: a prospectus on processes and resources of the Bering Sea Shelf. Public Inf.Bull.Inst.Mar.Sci., Univ.Alaska, (74-1):71 p.
1974

Low, Loh Lee, Derivation of catch per unit effort from commercial fishery statistics for the Bering Sea, 1964-73. Paper prepared for presentation to the Advisory Committee on Marine Resources Research Working Group on Fishing Effort and Monitoring of Fish Stock Abundance, 15-20 December 1975. Rome, FAO, 29 p.
1975

Pella, J.J. and P.K. Tomlinson, A generalized stock production model. Bull.I-ATTC, 13(3): 421-96
1969

Rothschild, B.J. and J.W. Balsiger, A linear-programming solution to salmon management. Fish.Bull.NOAA/NMFS, 69(1):117-38
1971

Schaefer, M.B., Some aspects of the dynamics of populations important to the management of commercial marine fisheries. Bull.I-ATTC, 1(2):26-56
1954

Walters, C.J., A generalized computer simulator model for fish population studies. Trans.Am.Fish.Soc., 98(3):505-12
1969

EFFECT OF MULTI-SPECIES FISHERIES ON THE MANAGEMENT OF HALIBUT STOCKS

by

Stephen H. Hoag

and

Bernard E. Skud

International Pacific Halibut Commission
Seattle, Washington
U.S.A.

CONTENTS

		Page
1.	INTRODUCTION	28
2.	THE INCIDENTAL CATCH OF HALIBUT	28
	2.1 Observer Programme	28
	2.2 Estimated Catches	29
	2.3 Effect on Stock Abundance	30
3.	GENERAL MANAGEMENT SOLUTIONS	31
4.	PRESENT AND FUTURE MANAGEMENT APPROACH	31
5.	SUMMARY	32
6.	REFERENCES	35

1. INTRODUCTION

In the North Pacific Ocean, Canadian and United States fishermen harvest halibut (Hippoglossus stenolepis) with setline gear. The International Pacific Halibut Commission (IPHC) regulates the fishery and prohibits the landing of net-caught halibut. Production of halibut was at its peak during the early 1960's but fell thereafter when IPHC allowed the catch to exceed the maximum sustained yield (MSY). This action was considered necessary to demonstrate that the stocks were fully utilized, a requisite for Japanese abstention under the International North Pacific Fisheries Commission (INPFC). Stock abundance fell as expected, and IPHC reduced the catch limit of the setline fishery, but the stock continued to decline. Although the trawl fisheries began before 1960, they were relatively small and their effect on the halibut stocks was minimal. During the 1960's, however, trawling by the domestic fleet (Canada and the United States) increased off British Columbia, and Japanese and Soviet trawl fisheries expanded in the Gulf of Alaska and the Bering Sea. These fisheries were directed at groundfish species other than halibut, but halibut were an incidental or by-catch.

The reductions in the setline catch were not sufficient to compensate for the increased mortality that resulted from the combined effort of setline and trawl fisheries (Skud, 1973). Total groundfish catches by the trawl fisheries were substantial, exceeding 3 000 000 mt annually, but the magnitude of the by-catch of halibut was unknown until the early 1970's. The incidental catch effectively weakened IPHC's management control and, in part, offset the conservation measures that were instituted in the setline fishery. Furthermore, IPHC's assessment of stock condition was hampered by a lack of information on the by-catch. Even now, the halibut catch is not reported directly, but rather is estimated by sampling the groundfish catch. Hoag (1971) and Hoag and French (Ms) showed that the incidental catch of halibut increased sharply during the 1960's and early 1970's, and in some areas exceeded the catch by the domestic setline fishery. The purposes of this paper are to review the management problems associated with the incidental catch of halibut in multi-species fisheries and to describe the measures recommended to alleviate these problems.

2. THE INCIDENTAL CATCH OF HALIBUT

2.1 Observer Programme

IPHC regulations prohibit the retention of halibut by domestic trawlers, and INPFC regulations prohibit retention by Japanese trawlers in the Gulf of Alaska and the eastern Bering Sea. Statistical records on the magnitude of the incidental catch of halibut are not available directly from either domestic or foreign trawl fisheries. The trawl fisheries target on more abundant species, e.g., pollock (Theragra chalcogramma), Pacific ocean perch (Sebastes alutus), and yellowfin sole (Limanda aspera), and the catch of halibut, which is usually a small part of the total catch, is generally included with other miscellaneous species. To estimate the incidental catch of halibut, IPHC relied on data collected by observers who sampled the catches of domestic, Japanese and U.S.S.R. trawlers.

Observer programmes were conducted on domestic and foreign trawlers. IPHC collected data on the incidence of halibut in domestic trawl catches off British Columbia between 1962 and 1970. Programmes on foreign vessels were initiated and coordinated by the U.S. National Marine Fisheries Service (NMFS) and included observers from state agencies and IPHC. Data were collected on Japanese vessels in the Gulf of Alaska from 1963 to 1969, on Japanese vessels in the Bering Sea from 1972 to 1975, and on U.S.S.R. vessels in the Gulf of Alaska and the Bering Sea during 1974-1975. Data were also collected by the Japanese Fisheries Agency from 1969 to 1973 in the Bering Sea.

Sampling on domestic and Japanese vessels was extensive, over 3 000 individual trawl hauls were examined on domestic trawlers, and the catch from over 1 000 days of fishing was sampled on Japanese vessels. Sampling on Japanese vessels was more difficult than on

domestic vessels because the catches were larger. On domestic trawlers, the total groundfish catch was usually less than 2 mt per haul and halibut were readily enumerated. On Japanese vessels, enumeration of the halibut was not possible; the catch from several hauls often was combined and might exceed 500 mt for the day. A sampling procedure was developed to estimate the catch of halibut by Japanese vessels, but it was often difficult to obtain a representative sample. For example, one method of sampling was to monitor the conveyor belt that transports the catch from the unloading bin to the factory (Miller, et al., in press). Because of the volume of fish and speed of the conveyor belt, not all of the halibut were counted and the incidental catch was underestimated.

The data collected from both domestic and Japanese trawlers provided information on the size, age, and viability of halibut as well as on the incidence of halibut, which was expressed either by weight as a percentage of the total groundfish catch or as the number of halibut per metric ton of groundfish. Data from these observer programmes have been used to estimate the incidental catch and to determine the seasonal and areal differences in the incidental catch.

2.2 Estimated Catches

Data from the observer programmes show that halibut were about 5% of the groundfish catch by domestic trawlers off British Columbia (Hoag, 1971) and about 1% of the groundfish catch by Japanese trawlers in the Bering Sea and the Gulf of Alaska (Hoag and French, Ms). Data from Soviet trawlers have not been sufficient to estimate the incidence. Most of the halibut were 3 to 7 years old, considerably younger than those caught by the setline fishery. The survival of halibut on Japanese trawlers was nil, due primarily to the time required to process the catch. The survival of halibut on domestic trawlers was about 50%, but the rate of survival differed considerably with size of halibut, time on deck, and weight of the total catch (Hoag, 1975).

The incidence of halibut differed among areas, seasons, and target species. In the domestic trawl fishery, the incidence was highest in Hecate Strait during the summer when fishing was concentrated on shallow-water species such as Pacific cod (Gadus macrocephalus) and rock sole (Lepidopsetta bilineata); the incidence often exceeded 10% and occasionally halibut was the dominant species. During the winter, the incidence was usually less than 1% and was that low during the summer when trawlers fished for deep-water species such as Pacific ocean perch and dover sole (Microstomus pacificus). Hoag (1971) estimated the annual incidental catch by extrapolating the incidence to the total groundfish catch. The results showed that the incidental catch increased from about 1 000 mt in 1962 to 2 000 mt in 1969.

Differences in the incidence also occurred in the Japanese fishery although the seasonal rate was the opposite of that in the domestic fishery, i.e., the incidence was higher during the winter than in the summer. The incidence also varied by area and was higher in the southeastern Bering Sea and the Gulf of Alaska than in the central and western Bering Sea. The observed differences in the incidence among areas conform closely with the known distribution of halibut, and the seasonal differences can be explained by seasonal changes in the depth-distribution of halibut. Halibut generally are in depths over 200 meters during the winter and less than 100 meters during the summer. Hoag and French (Ms) estimated that the Japanese and Soviet incidental catch increased from less than 1 000 mt annually before 1960 to about 10 000 mt in 1965. Most of the catch during the mid-1960's was in the Gulf of Alaska, the majority by U.S.S.R. trawlers. In the late 1960's, the incidental catch declined sharply in the Gulf, but there was a corresponding increase in the Bering Sea by Japanese and Soviet trawlers.

Although considerable data have been collected on the incidence of halibut in trawl catches, the estimates of catch were subject to error because data were limited or lacking in many months, areas, and years. Because of these limitations, several adjustments were made to estimate the incidental catch. First, because data were not available in all years,

it was necessary to assume that annual differences in the incidence among years were not significant even though changes have occurred in the population size of halibut and groundfish, in the gear, and in the target species. Each of these factors could affect the incidence of halibut in the total catch. Second, the catch in area-months where data were not available were interpolated from adjacent areas. Third, data from Soviet trawlers were not sufficient to estimate their incidental catch, and the incidence observed on Japanese trawlers was assumed to be the same as that on Soviet trawlers. This assumption may not be valid because of differences in the gear used by Japanese and Soviet trawlers. Evidence suggests that U.S.S.R. trawls are fished slightly off bottom for some species. Estimating the U.S.S.R. catch was further complicated because the statistics of their total groundfish catch are questionable; NMFS scientists have reported major discrepancies in the magnitude and location of the Soviet catch when compared to the fishery activities documented by aerial surveillance reports from the U.S. National Marine Fisheries Service. Although the above adjustments may introduce errors in the data, the estimates provide a measure of the magnitude of the incidental catch.

2.3 Effect on Stock Abundance

The estimates show that the incidental catch of halibut increased substantially during the 1960's and early 1970's, whereas the catch and CPUE by North American setline vessels declined sharply during the same period. Further, the decline in the catch of halibut by setliners has been only slightly more than the increase in the catch by trawls, a superficial indication that trawling has been a major factor affecting stock abundance. However, the effect has not been uniform in all areas and years, and factors other than trawling have contributed to the decline in setline catches.

There are several problems involved with assessing the effect of trawl catches on the setline fishery. Most halibut in the trawl catch are 4 to 7 years old; they are 8 to 15 years old in the setline catch. Therefore, trawling primarily reduced the number of young halibut entering the setline fishery, and much of the loss to the setline fishery occurred years after trawl-capture. Also, reliable estimates of natural mortality are not available for juvenile halibut (less than 8 years old) and an estimate of natural mortality is critical in the assessment of the effect of trawling on the setline fishery. A high natural mortality would greatly reduce the effect of trawling because many of the fish caught by trawlers would never have been available to setline gear. Further, some halibut migrate from the Bering Sea to the northeast Pacific. Therefore, trawl catches in the Bering Sea affect the setline fishery in the northeast Pacific.

The effect of trawling was examined in two ways. First, the effect on recruitment was examined by comparing trends in the abundance of juveniles with trends in the catch of juveniles by Japanese and Soviet trawlers. Estimates of abundance, indicated by CPUE, were available from IPHC's annual recruitment surveys (Best, Ms.). Second, the potential yield loss to the setline fishery was estimated from a yield model that accounts for changes in biomass that occur between the time of trawl-capture and the time of setline-capture. The results from this analysis are preliminary but indicate that the expansion of the trawl fishery has reduced recruitment to the setline fishery and that the loss in potential yield was substantial.

However, the initial decline in catch and CPUE that occurred in the setline fishery in the early 1960's cannot be attributed to incidental catches by trawlers (Skud, 1973). Trawl catches were relatively small until the mid-1960's and should not have affected the setline fishery until the late 1960's. Trawl-caught halibut are younger than those recruited to the setline fishery. Apparently, the initial decline was from excessive removals by the setline fishery or from reduced recruitment, perhaps due to adverse environmental conditions. Nevertheless, the large incidental catch in recent years has negated restrictions placed on the setline fishery, and a reduction in incidental catch is required before the catch in the setline fishery can be increased, i.e., until stock abundance improves.

3. GENERAL MANAGEMENT SOLUTIONS

Incidental catches in multi-species trawl fisheries are not peculiar to halibut. Other highly desirable species such as crabs, haddock, and lobsters are also taken as by-catches. These species are in great demand and usually are exploited at or near the maximum level for the resource by single-species fisheries. If these single-species fisheries are to be maintained, some means must be made to accommodate them by alleviating the problems created by multi-species fisheries. One approach would be to collate catch statistics with biological and economic data and systematically schedule fishing operations to obtain optimal utilization from both fisheries. For example, the incidental catch of halibut changed with area and depth as well as by season and target species. With proper timing and distribution of trawl effort, the incidental catch of halibut could be substantially reduced, i.e., by restricting trawl fishing on specific grounds when by-catches are highest. At the same time, ample opportunity could be afforded for trawl fishing on other grounds so that the production by trawlers would not be seriously affected. Restricted grounds could be open to trawling when by-catches of halibut were low, and the total catch of the target species on these grounds probably would not change significantly.

Another approach would be to modify trawl gear to reduce the incidental catch of species already exploited by single-species fisheries. Recent studies by the U.S. National Marine Fisheries Service (Ellis, unpublished) show that the catch of halibut is substantially reduced if the groundline of the trawl is over 0.5 meters off bottom. The effect of off-bottom trawling on the catch of groundfish has not been adequately assessed, but the catch of species which are not directly on bottom probably would not change. Similarly, the use of bobbins or rollers on the groundline of trawls (designed to protect the trawl on rough bottom) reduces the incidental catch of on-bottom species such as halibut and crab by raising the groundline off the bottom. Reductions in the catch of small halibut were observed in some Japanese trawls using such gear (IPHC, 1974). Other adjustments on trawls may also reduce incidental catches. One U.S.S.R. trawler was observed using additional floats on the net to raise the trawl off bottom; catches of pollock (the target species) were substantial, yet halibut and crab catches were nil (NMFS, unpublished).

Research on multi-species fisheries is urgently needed to determine whether adjustments in trawl effort, gear modifications, or other means offer practical solutions to reducing incidental catches in multi-species fisheries. If incidental catches cannot be reduced, then means must be found for optimizing the use of all species within the multi-species fisheries. For species such as halibut, that are vulnerable to trawls at suboptimum ages, yields from trawl fisheries will be below the maximum. However, regulations that prohibit the retention of incidentally-caught species may reduce yields even further if the incidental catch is high and the survival of released fish is low. Allowing retention of the incidental catch would increase the yield loss to the single-species fisheries, but would convert some of this loss to production by the multi-species fisheries. Also, allowing retention of the by-catch may improve the accuracy of statistics on incidental catches in multi-species fisheries and, in turn, contribute to better management.

4. PRESENT AND FUTURE MANAGEMENT APPROACH

Realizing the importance of the productive trawl fisheries and recognizing that foreign trawling will likely continue, even if national fishery zones are extended, IPHC proposed a scheme to reduce the incidental catch of halibut without serious curtailment of the trawl fishery. In 1973, IPHC proposed that foreign trawling be prohibited in particular areas in the Bering Sea when the incidence of halibut was high but trawl effort was low. Other areas would remain open to trawling year-round, and the closed areas would reopen to fishing at times when the incidental catch of halibut was low, thereby allowing time and area to conduct a productive trawl fishery. The governments of Canada and the United States supported the IPHC proposal and, through negotiations, the Japanese agreed to most of the closures. In response to a second proposal by IPHC in 1974, negotiations continued and

Japan agreed to expand the direction and area of the Bering Sea closures for 1975. In addition, Japan agreed to several closed areas in the Gulf of Alaska. Canada and the United States discussed these closures with the U.S.S.R. and similar agreements were reached for 1976. Figures 1 and 2 show the area and time of trawl closures. These closures will reduce the incidental catch of halibut by several thousand metric tons and improve the recruitment of halibut to the setline fishery.

In essence, IPHC's proposal was an attempt to cope with problems of high-seas multi-species fisheries. Even though extended jurisdiction was on the horizon, IPHC felt that immediate action was necessary to reduce the incidental catch. Further, IPHC recognized that extended jurisdiction will not eliminate the incidental catch of halibut by foreign fishermen. If, however, the coastal nations can control the incidental catch by modifying the conduct of the trawl fishery, it will be possible to protect halibut stocks while allowing other fisheries to operate profitably.

IPHC has also examined means of reducing losses from incidental catches by domestic trawlers. The problem is similar to that encountered with the foreign trawl fisheries in that it involves a multi-species fishery and several management agencies. In 1975, IPHC recommended that Canada and the United States increase their research effort to reduce the incidental catch by the domestic trawl fishery and develop management regimes which permit the optimum catch of halibut and other groundfish. Although further study is needed, a reduction in the loss from domestic trawlers could be achieved by modifying the trawl fishery to reduce the incidental catch or allowing limited retention of halibut by domestic trawlers to convert part of the loss into production or by combining aspects of both methods. Several alternative schemes of management should be considered, some of which may be impractical because of social, economic, and enforcement problems. Individually, schemes could adversely affect either the trawl or setline fisheries, but a combination of schemes could improve the catch of halibut without reducing the catch of other groundfish.

5. SUMMARY

IPHC regulates the domestic fishery for halibut and prohibits the landing of net-caught halibut. Halibut are fished with setlines but are also caught as an incidental or by-catch in the domestic and foreign trawl fisheries. During the 1960's, trawling increased sharply, but the magnitude of the incidental catch was unknown. To estimate the incidental catch, IPHC relied on data collected by observers on domestic, Japanes, and Soviet trawlers. The results from the oberserver programmes showed that the by-catch increased substantially during the 1960's and early 1970's. The increase in the incidental catch coincided with a decrease in the catch by setliners. Although trawling was not the only factor affecting stock abundance, the large incidental catch negated restrictions placed on the setline fishery.

IPHC examined several means to reduce the incidental catch without serious curtailment of the trawl fisheries. Data from the observer programmes showed that the incidental catch varied among areas and seasons. On the basis of these results, IPHC proposed that trawling be prohibited in particular areas when the incidental catch of halibut was high but trawl effort was low. The governments of Canada and the United States supported IPHC's proposal and, through negotiations, the Japanese agreed to most of the closures. Similar closures have recently been agreed to by the U.S.S.R. IPHC has also examined means of reducing losses from incidental catches by domestic trawlers. These include modification of the trawl fishery to reduce the incidental catch and allowance of halibut retention by trawls to convert some of the loss into production.

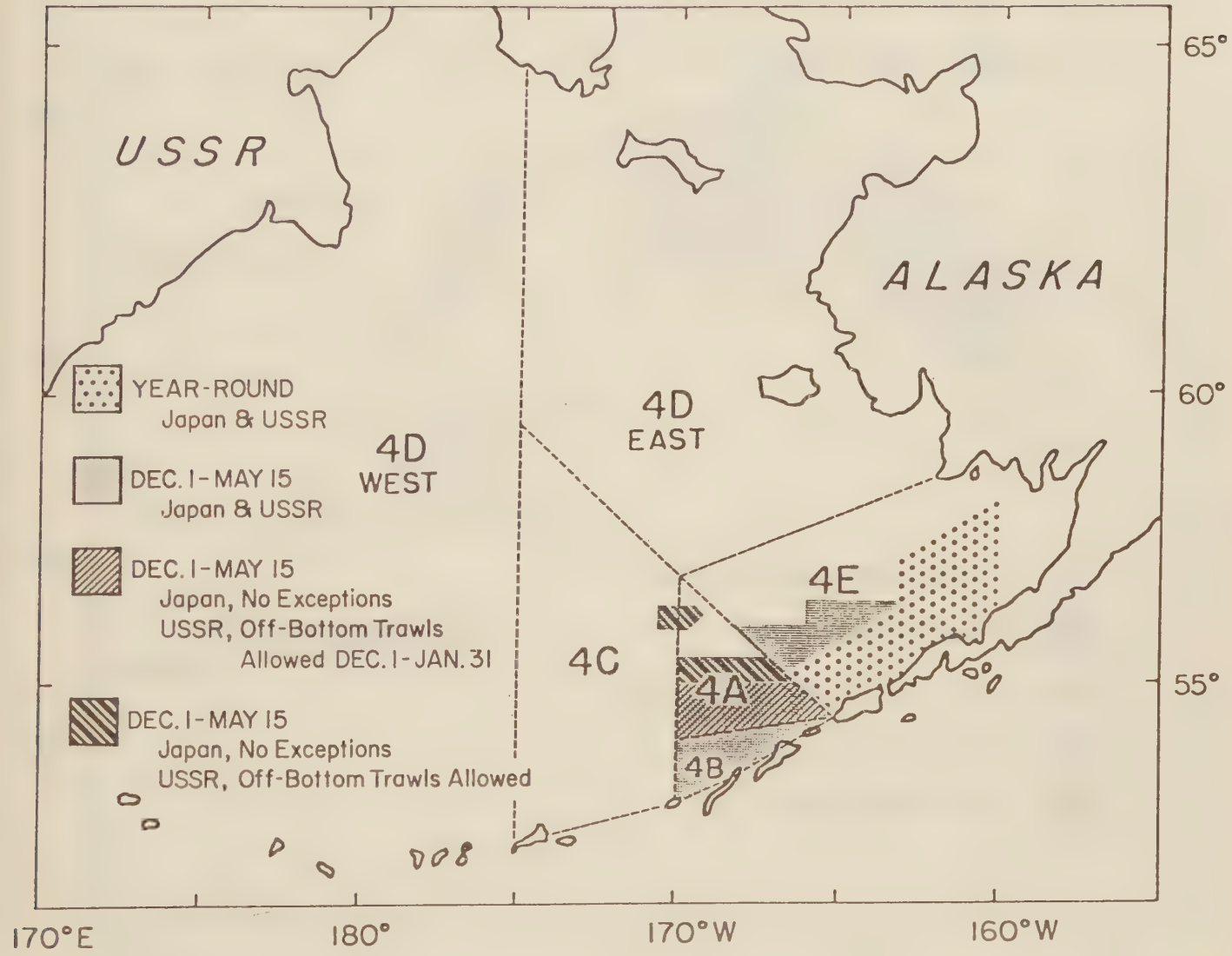


Figure 1: Japanese and Soviet trawl closures in the Bering Sea

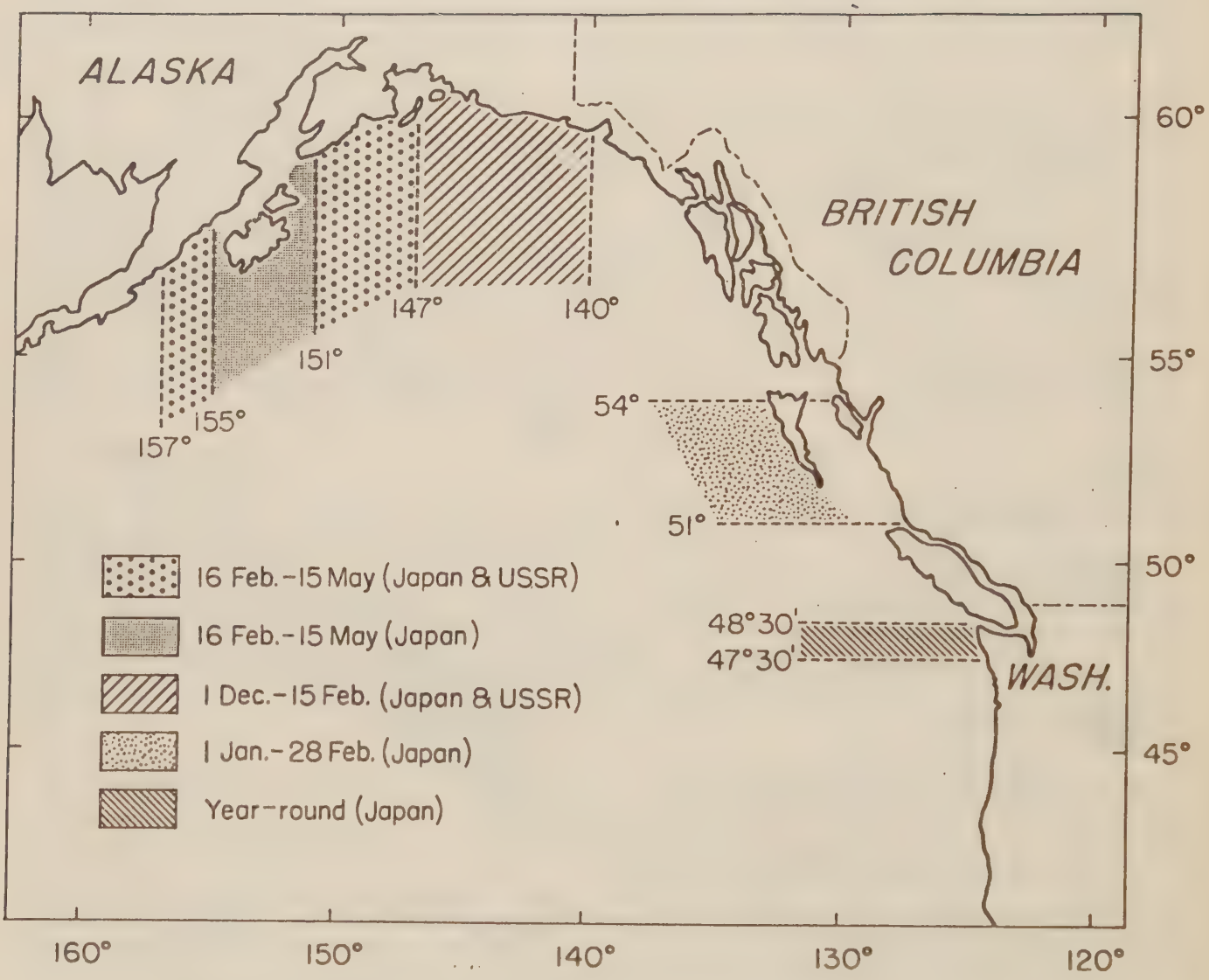


Figure 2: Japanese and Soviet trawl closures in the Gulf of Alaska

6. REFERENCES

Hoag, S.H., 1971 Effects of domestic trawling on the halibut stocks of British Columbia. Sci.Rep.IPHC, (53):18 p.

_____, 1975 Survival of halibut released after capture by trawls. Sci.Rep.IPHC, (57): 18 p.

IPHC, 1974 Annual report 1973. Annu.Rep.IPHC, (1973):52 p.

Miller, M. et al., U.S. observers board Japanese trawl vessels in Bering Sea (in press)

Skud, B.E., 1973 Management of the Pacific halibut fishery. J.Fish.Res.Board Can., 30(12) Part 2:2393-8

THE EFFECTS OF CHANGING JURISDICTIONAL AND MANAGEMENT CONCEPTS ON THE OCEAN'S LIVING RESOURCES AND ENVIRONMENT - THE POTENTIAL IMPACT ON FISHERIES SCIENCE

by

Dayton L. Alverson
Northwest Fisheries Center
National Marine Fisheries Service
Seattle, Washington 98112
U.S.A.

CONTENTS

		Page
1.	INTRODUCTION	38
2.	FISHERIES SCIENCE IN THE POST-WORLD WAR II ERA	38
3.	MANDATE FOR CHANGE	40
4.	THE CONSEQUENCES OF JURISDICTIONAL AND PHILOSOPHICAL CHANGES	50
5.	SUMMARY AND CONCLUSIONS	52
6.	REFERENCES	

1. INTRODUCTION

Several years ago, a former scientific advisor to the British Government, Sir Solly Zuckerman, stated:

> We live in a period of uncontrolled and accelerated change, an age in which technology has raced ahead and in which hallowed social values have tumbled ...
> We live in an age of paradox: an age in which the politician has been straining after the scientists and technologist, and in which the latter have been trying to understand the social consequences of the innovations to which their work has led. The world is clearly living through a period in which the aims of politics and the outcome of scientific endeavour appear to clash.

This quotation is particularly germane to the current turmoil and confusion regarding freedom of seas, ownership of ocean resources, rights of national and international entities to control and prevent oil pollution, and the right of coastal states to limit scientific research. These contentious issues are all currently being debated by the Third Law of the Sea Conference, as well as in many regional and national forums.

Although the character of a new legal regime which may emerge from the Conference or which may evolve as a result of unilateral actions is difficult to forecast, it is becoming increasingly evident that many of the historical freedoms associated with the high seas will be sharply modified, particularly as they relate to geographic areas that may come under the jurisdiction of coastal states.

To some extent, the changing views on jurisdiction vested in national entities versus the international community may have been inspired by questionable goals associated with managing ocean resources. The objective of managing to achieve the maximum sustainable yield of resources exclusive of other economic or sociological objectives has been challenged by a number of economists and sociologists. More recently, the utility of MSY has been questioned in terms of its viability as a theory in a technical sense; and a growing number of management failures has stimulated scientists to consider alternative goals and techniques for managing natural resources. At the same time, conservationists and scientists have considered new functional definitions for "conservation" and their application to resource management.

It is the purpose of this paper to examine the character of jurisdictional changes and policies which may alter management goals and to evaluate their impact on the conduct and execution of fisheries science.

2. FISHERIES SCIENCE IN THE POST-WORLD WAR II ERA

Fisheries science grew rapidly in the post-World War II era, particularly during the period of expanding high seas fishing activities. The concept of large-scale, multi-nation cooperative studies apparently was initiated in the North Atlantic and North Pacific, and multi-national fisheries investigations in waters seaward of the territorial sea were common, particularly during the decades of the 1950's and 1960's. During this period, scientists had rather free access to ocean areas, particularly in the Northern Hemisphere, seaward of coastal states territorial limits. Multi-national fisheries science was facilitated through international fisheries commissions such as the International Commission for North Atlantic Fisheries (ICNAF), the International North Pacific Fisheries Commission (INPFC), and the Inter-American Tropical Tuna Commission (IATTC); and through international scientific groups, e.g., IOC and ICES; as well as by efforts of the Department of Fisheries of FAO.

Traditional freedoms associated with scientific activity in the world's ocean began to errode, first as a result of unilateral extension of territorial seas by South American countries, and subsequently by international treaty arrangements which were a product of the 1958 Law of the Sea Conference. Several nations which extended their territorial jurisdiction to 200 miles at the same time required fisheries science and fisheries activities in general to be conducted only on a "consent" basis.

Another major step in limiting scientific freedom was taken during the 1958 LOS Conference, which in the Convention on the Continental Shelf (Article 5, Paragraph 8) stated: "The consent of the coastal state shall be obtained in respect to any research concerning the continental shelf and undertaken there ..." Although this language was intended to deal largely with the scientific activity related to the geological aspects of the shelf and to inanimate resources, studies related to certain sedimentary resources also required consent of the coastal state.

Although I have not examined in any detail the consequence of extended jurisdiction in the Southern Hemisphere and impact of the consent requirement of the Continental Shelf Act, it does not appear that these actions have substantially altered or interfered with the conduct of high-seas fisheries studies. Both acts were perhaps more legalistic in character in influencing the nature of rights rather than interfering directly with high-seas fisheries investigations. The fact that they did not impede the execution of fisheries investigations may in part reflect the fact that large-scale high-seas fisheries studies during the 1950's and 1960's largely occurred in the Northern Hemisphere or other areas of the world's ocean which were still considered (seaward of territorial sea) open access in terms of conducting fisheries science or were conducted in the water column and, hence, not subject to consent requirements.

During the period between 1958 and the present time, however, a number of additional countries extended their territorial or fisheries zones, and at the same time required consent for fisheries science conducted in areas coming under their jurisdiction. These actions did impact on fisheries science, although not on a large scale. Regardless, they delayed or prevented initiation of fisheries studies.

We must accept the fact that in the three decades following World War II there have been rather substantial jurisdictional changes which have increased the complexity of conducting fisheries science in the world's ocean. At this point, it is perhaps fair to state that the changes to date have not resulted in major impediments inasmuch as a variety of well-established international fisheries institutions have assisted in the planning and execution of such activities. At any rate, they must be considered insignificant in terms of the impacts which may result from jurisdictional changes formulated at the Third Law of the Sea Conference.

The post-World War II era must also be identified as a period during which the concept of exploiting ocean resources consistent with their maximum sustainable yield (MSY) became accepted as a universal standard. It can be characterized as an era of feverish investigation to assess the distribution, abundance, and behavioural characteristics of fisheries resources in order to establish the surplus yield which could be extracted from them at various population levels. The concept of MSY, which was originally established as a parameter of mathematical model, was gradually introduced as a basic management objective. On the assumption that a particular model appropriately reflected the behaviour of a stock or stocks to exploitation, the concept of MSY permitted investigators to theoretically evaluate the impact of exploitive activities and to establish an acceptable rationale for national and international management.

The problems, however, of defining the MSY in a statistical and philosophical sense, began to emerge during the 1960's — a period when a number of fisheries scientists began to question the wisdom of using MSY as a management goal and to question its philosophical basis for managing species complexes. A rather substantial review of the issue was recently published in the Proceedings of a symposium held during the 104th Annual Meeting of the American Fisheries Society (Roedel, 1975). The preface of this report states that, "The traditional view of maximum sustainable yield as the philosophical basis for fisheries management programmes has come under increasing attack over the last decade or so."

Disillusionment with MSY as a management goal (Alverson, 1975) has led to several alternative goals being proposed: e.g., optimum yield, optimum sustainable yield, optimum ecological management, etc. In addition, there have been attempts to redefine conservation, consistent with operational goals. Hence, parallel with changing jurisdictional views, there has been in the last few years attempts by scientists, politicians, and the general public to redefine management goals for the ocean living resources and to revaluate the scientific basis for decison making in this area.

3. MANDATE FOR CHANGE

Despite a number of pleas to the world community by leading scientists, philosophers, etc., that compartmentalization of the oceans in terms of extended economic zones and/or territorial seas will greatly inhibit the conduct of ocean sciences, other forces are mandating change in the behaviour of man's actions on the ocean. The proposed Law of the Sea changes in jurisdictional concepts reflect a major philosophical change and may have profound effects on the conduct and performance of fisheries science. Language which specifically deals with this issue in the LOS documents can be found in the Informal Single Negotiating Text, Part 3 (Document A/CONF.62/WP.8/PART III). In order to provide an unabridge version of the LOS document, I have quoted in its entirety Chapters 1-6 which deal with marine scientific research:

MARINE SCIENTIFIC RESEARCH

CHAPTER ONE

GENERAL PROVISIONS

Article 1

Marine scientific research means any study or related experimental work designed to increase man's knowledge of the marine environment.1/

Article 2

All States, whether coastal or land-locked, as well as appropriate international organizations have the right to conduct marine scientific research subject to provisions of this Convention.

Article 3

States shall endeavour to promote and facilitate in accordance with the provisions of this Convention the development and conduct of marine scientific research not only for their own benefit but also for the benefit of the international community.

Article 4

States and international organizations shall apply in the conduct of marine scientific research the following principles:

(a) marine scientific research activities shall be conducted exclusively for peaceful purposes;

(b) such activities shall not unduly interfere with other legitimate uses of the sea compatible with the provisions of this Convention and shall be duly respected in the course of such uses;

1/ A provision containing a definition of marine scientific research could be embodied in a special introductory chapter of this Convention together with all other definitions.

(c) such activities shall comply with regulations established in conformity with the provisions of this Convention, for the preservation of the marine environment.

Article 5

Marine scientific research shall be conducted subject to the rights of coastal States as provided for in this Convention.

Article 6

In conducting marine scientific research in accordance with the provisions of this Convention States and competent international organizations shall use appropriate scientific methods and may utilize vessels, aircraft, devices, equipment or installations.

Article 7

Marine scientific research activities shall not form the legal basis for any claim whatsoever to any part of the marine environment or its resources.

CHAPTER TWO

INTERNATIONAL AND REGIONAL CO-OPERATION

Article 8

States shall, in accordance with the principle of respect for sovereignty and on the basis of mutual benefit, promote international co-operation in marine scientific research for peaceful purposes.

Article 9

States shall co-operate with one another, through the conclusion of bilateral and mutlilateral agreements, to create favourable conditions for the conduct of scientific research in the marine environment and to integrate the efforts by scientists in studying the essence of and the interrelations between phenomena and processes occurring in the marine environment.

Article 10

States shall, both individually, and in co-operation with other States and with competent international organizations, actively promote the flow of scientific data and information and the transfer of knowledge resulting from marine scientific research in particular to developing countries, as well as the strengthening of the autonomous marine research capabilities of developing countries through, inter alia, programmes to provide adequate education and training of their technical and scientific personnel.

Article 11

The availability to every State of information and knowledge resulting from marine scientific research shall be facilitated by effective international communication of proposed major programmes and their objectives, and by publication and dissemination of the results through international channels.

Article 12

States and international organizations shall endeavour to facilitate marine scientific research through bilateral or regional and other multilateral agreements.

CHAPTER THREE

CONDUCT AND PROMOTION OF MARINE SCIENTIFIC RESEARCH

Article 13

Coastal States have the exclusive right to conduct and regulate marine scientific research in their territorial sea. Scientific research activities therein shall be conducted only with the explicit consent of, and under the conditions set forth by the coastal State. Requests for such consent shall be submitted to the coastal State well in advance and shall be answered without undue delay.

Article 14

Marine scientific research beyond the territorial sea, in the economic zone and the continental shelf, shall be conducted by States as well as by appropriate international organizations in such a manner that the rights of the coastal State, as provided for in this Convention, are respected.

Article 15

States and international organizations which intend to undertake scientific research in the economic zone or on the continental shelf of a coastal State shall provide that State with a full description of:

(a) the nature and objectives of the research project;

(b) the means to be used, including name, tonnage, type and class of vessels;

(c) the precise geographical areas in which the activities are to be conducted;

(d) the expected date of first appearance and final departure of the research vessels or equipment as the case may be; and

(e) the name of the sponsoring institution, its director and the scientist(s) in charge of the expedition.

Article 16

States and international organizations when undertaking scientific research shall comply with the following conditions:

(a) ensure the rights of the coastal State, if it so desired, to participate or to be represented in the research project;

(b) provide the coastal State an opportunity to participate directly or be represented, if it so desires, in the research on board vessels at the expense of the State conducting the research but without payment of any remuneration to the scientist of the coastal State;

(c) provide the coastal State with the final results and conclusions of the research project;

(d) undertake to provide to the coastal State on agreed basis raw and processed data and samples of material;

(e) if requested, assist the coastal State in assessing the said data and samples and the results thereof;

(f) ensure that the research results are made internationally available through International Data Centres or through other appropriate international channels as soon as feasible;

(g) inform the coastal State immediately of any major change in the research programme; and

(h) comply with all relevant provisions of this Convention.

Article 17

The communication concerning the research project shall be made through appropriate official channels and the coastal State shall acknowledge its receipt immediately.

Article 18

1. States and international organizations, which intend to undertake scientific research shall indicate in their communication to the coastal State whether they consider the research project to be of a fundamental nature or related to the resources of the economic zone or continental shelf.

2. States shall seek to promote through competent international organizations the establishment of criteria and guidelines concerning the differentiation between research directly related to the exploration and exploitation of the living and non-living resources and fundamental research which is not directly related to exploration and exploitation of such resources.

Article 19

If the coastal State considers that the research project defined by the researching State as fundamental is not of such nature, it may object only

on the ground that the said project would infringe on its rights as defined in this Convention over the natural resources of the economic zone, or continental shelf.

Article 20

Any dispute with respect to the determination of the nature of the research project, if not settled by negotiation between the parties concerned shall, at the request of any of the parties of the dispute, be submitted for settlement in accordance with the procedures set out in the relevant articles of this Convention.

Article 21

Any research project related to the living and non-living resources of the economic zone and the continental shelf shall be conducted only with the explicit consent of the coastal State. In this case the following conditions shall apply:

(a) the conditions specified in Articles 15 and 16 with the exception of condition (f) of Article 16;

(b) if requested, submit to the coastal State as soon as practicable after the completion of the research, a report including a preliminary interpretation;

(c) ensure that the research results are not published or made internationally available without the express consent of the coastal State; and

(d) fulfil any other request for information relating directly to the research project.

Article 22

When the research is of fundamental nature the coastal State may indiciate within ___ days of the communication concerning the research project its intent to participate in the different phases of the research on mutually agreed terms. In case the coastal State does not reply, the researching State or the international organization shall proceed with the realization of research project in accordance with the conditions referred to in Article 16.

Article 23

1. States and international organizations conducting marine scientific research in the economic zone of a coastal State shall take into account the interest, and rights of the land-locked and other geographically disadvantaged States of the region, neighbouring to the research area, as provided for in this Convention, and shall notify these States of the proposed research project as well as provide, at their request, relevant information and assistance as specified in Article 15 and Article 16 sub-paragraphs (e) and (g).

2. Such neighbouring land-locked and other geographically disadvantaged States shall, at their request, be given the opportunity to participate, whenever feasible in the proposed research project through qualified experts to be appointed by them.

Article 24

Coastal states shall on the basis of bilateral or regional and other multilateral agreements and in a spirit of international co-operation with a view to promoting marine scientific research activities conducted in accordance with this Convention, adopt measures, including domestic legislation, to facilitate access to their harbours and to provide assistance for marine scientific research vessels carrying on such activities.

Article 25

1. All States, whether coastal or land-locked, as well as appropriate international organizations shall have the right in conformity with the provisions of this Convention to conduct marine scientific research in the international sea-bed area.

2. Information concerning the research project in accordance with Article 15 shall be submitted not less than _____ days beforehand to the International Sea-Bed Authority, established in accordance with the provisions of this Convention.

3. When a resource oriented marine scientific research programme is planned in an area immediately adjacent to the economic zone or continental shelf of a coastal State, and research incidental to the research programme, involving entries into the economic zone of the coastal State may be required, the coastal State may request that the provisions of Article 21 be fulfilled.

4. The research results should be published in a readily available scientific publication, and in any event made internationally available through appropriate international channels, as soon as possible.

Article 26

All States whether coastal or land-locked as well as appropriate international organizations shall have the right in conformity with the provisions of this Convention to conduct marine scientific research in the waters of the high seas beyond the limits of the economic zone.

CHAPTER FOUR

STATUS OF SCIENTIFIC EQUIPMENT IN THE MARINE ENVIRONMENT

Article 27

The development and use of any type of scientific research installations or equipment in the marine environment shall be subject to the same conditions as those for the conduct of marine scientific research, as provided for in this Convention.

Article 28

All the rights necessary to operate and manage and the responsibility for such installations or equipment shall remain with the States or the international organizations which have deployed them or on whose behalf they have been deployed, in accordance with the provisions of this Convention, unless otherwise agreed between the parties concerned.

Article 29

In areas where the consent of the coastal State is needed for the conduct of marine scientific research in accordance with this Convention the coastal State has the power to inspect and ensure that the installations or equipment are used in conformity with the purposes and conditions set out for the conduct of the research project, including the right, in the case of contravention by the deploying States or international organizations, to take all appropriate judicial and administrative measures.

Article 30

The installations or equipment referred to in this Chapter shall not have the status of islands or possess their own territorial sea, continental shelf or economic zone of the coastal State.

Article 31

Safety zones of a width not exceeding ___ metres measured from the outermost points of the installations referred to in this Chapter may be created around the installations. All States shall ensure that such safety zones are respected by their ships.

Article 32

The deployment and use of any type of scientific research installations or equipment must not constitute an obstacle to the established international shipping routes.

Article 33

Installations or equipment referred to in this Chapter shall bear indentification markings indicating the State or international organization to which they belong and will have adequate warning signals to ensure the safety of sea and air navigation.

CHAPTER FIVE

RESPONSIBILITY AND LIABILITY

Article 34

States and competent international organizations shall be responsible for ensuring that marine scientific research, whether undertaken by them or on their behalf, is conducted in accordance with the provisions of this Convention.

They shall be liable in conformity with international law for damage arising out of marine scientific research undertaken by them or on their behalf.

Article 35

1. States shall also take the necessary legislative or regulatory measures to prohibit any conduct of marine scientific research by their nationals, natural or juridicial, or by other persons under their jurisdiciton, which is in contravention of the provisions of this Convention and to establish sanctions therefore.

2. States shall ensure that recourse is available in accordance with their legal systems for compensation or other relief in respect of damages arising out of marine scientific research.

3. The liability in respect of damage caused within the area under jurisdiction and/or sovereignty of a coastal State arising from marine scientific research activities shall be governed by the law of the coastal State, taking into account the relevant principles of international law.

Article 36

States undertake to co-operate in the development of international law relating to procedures for the assessment of damage, the determination of liability, the payment of compensation and the settlement of related disputes.

CHAPTER SIX

SETTLEMENT OF DISPUTES

Article 37

Any dispute with respect to the interpretation or application of the provisions of this Convention with respect to marine scientific research shall be resolved by the dispute settlement procedures contained in Chapter ____ of this Convention.

The above material reflects the subcommittee chairman's view of an informal negotiating text. The President of the Conference notes that these documents must "...not in any way be regarded as affecting either the status or proposals already made by delegations or the right of the delegations to submit amendments or new proposals."

As regards scientific activities in the ocean, there is some confusion in the Conference deliberations inasmuch as the subject is alluded to in almost all the subcommittee reports. For example, in the Informal Single Negotiating Text, Part 2, of the Second Subcommittee, one can also find articles dealing with scientific activities under the title, "The Exclusive Economic Zone." Article 49 of this document states:

> The consent of the coastal State shall be obtained in respect of any research concerning the exclusive economic zone and undertaken there. Nevertheless, the coastal State shall not normally withhold its consent if the request is submitted by a qualified institution with a view to purely scientific research, subject to the proviso that the coastal State shall have the right, if it so desires, to participate or to be represented in the research, and that the results shall be published after consultation with the Coastal State concerned.

The language in the LOS documents speaks for itself, and it is apparent that regardless of which version (Part 2 or Part 3) of the Informal Single Negotiating Text is ultimately adopted, both imply major departures from historical legal patterns.

The LOS Conference may provide a legal environment somewhat less restrictive than that implied in the above material; but it is unlikely. At this point in time, I have chosen to evaluate the future impacts of jurisdictional change, based on the assumption that either a consent regime or a consent/obligation regime similar to that defined in Part 3 of the Single Negotiating Text will prevail and hence structure the environment under which we must operate in the future — that is, when conducting science in the economic zone of another state. Some general language may also find its way into the LOS text which may require certain procedures to be followed, even when conducting science seaward of an established economic zone.

In addition to jurisdictional changes, the LOS documents appear to modify traditional goals of fisheries management. In Part 2 of the Informal Single Negotiating Text, Article 50 states:

> 1. The coastal State shall determine the allowable catch of the living resources in its exclusive economic zone.
>
> 2. The coastal State, taking into account the best evidence available to it, shall ensure through proper conservation and management measures that the maintenance of the living resources in the exclusive economic zone is not endangered by over-exploitation. As appropriate, the coastal State and relevant subregional, regional and global organizations shall cooperate to this end.
>
> 3. Such measures shall also be designed to maintain or restore populations of harvested species at levels which can produce the maximum sustainable yield, as qualified by relevant environmental and economic factors, including the economic needs of coastal fishing communities and the special requirements of developing countries, and taking into account fishing patterns, the inter-dependence of stocks and any generally recommended subregional, regional, or global minimum standards.
>
> 4. In establishing such measures the coastal State shall take into consideration the effects of species associated with or dependent upon harvested species with a view to maintaining or restoring populations of such associated or dependent species above levels at which their reproduction may become seriously threatened.
>
> 5. Available scientific information, catch and fishing efforts statistics and other data relevant to the conservation of fish stocks shall be contributed and exchanged on a regular basis through subregional, regional and global organizations where appropriate and with participation by all States concerned, including States whose nationals are allowed to fish in the exclusive economic zone.

In the third paragraph of this Article, the conservation and management measures have the goal of being designed to maintain or restore populations of harvested species at levels which can produce the "maximum sustainable yield" but modified on the basis of relevant sociological or economic factors, including the economic needs of the coastal fishing community and species requirements of developing countries.

Under Article 51 (Part 2 of the Informal Single Negotiating Text) the goal of fisheries management is stated in terms of "optimum utilization" of living resources in the economic zone. The term "optimum utilization" is, however, left undefined. Several recent publications elaborate on the concept of optimum sustainable yield and provide new definitional approaches to the concept of conservation. I have alluded earlier to the publication of the American Fisheries Society concerning optimum sustainable yield as a concept for

fisheries management. Within this opus, the authors discuss "optimization" in terms of various goals and objectives of fisheries management vis-a-vis the concept of maximizing sustainable physical yield.

Recent debates on this subject are having a major impact on legislators and policy makers, and there are attempts to incorporate language into national legislation in the U.S. to alter the principles and policies of national and international fisheries management. A document published by the American Society of International Law (1974) proposed that the goal of international fisheries management should be to "maximize opportunities of individual states acting individually or collectively, depending on the characteristics of the particular fishery under consideration."

In addition to the symposium proceedings published on optimum sustainable yield by the American Fisheries Society, the World Wildlife Fund has recently distributed a report generated by a workshop on the conservation of wild living resources. The workshop undertook a critical review of the scientific basis for existing goals of conservation and prepared an interpretation of their new proposal with respect to the U.N. Law of the Sea Conference. The group proposed several principles and definitions which are worthy of the Committee's (ACMRR) inspection. The report of the workshop states that:

> The privilege of utilizing a resource carries with it the obligation to adhere to the following four general principles:
>
> 1. The ecosystem should be maintained in a desirable state such that
>
> (a) consumptive and non-consumptive values can be maximized on a continuing basis
>
> (b) present and future options are ensured
>
> (c) risk of irreversible change of long-term adverse effects as a result of use is minimized
>
> 2. Management decisions should include a safety factor to allow for the facts that knowledge is limited and institutions are imperfect.
>
> 3. Measures to conserve a wild living resource should be formulated and applied so as to avoid wasteful use of other resources.
>
> 4. Survey or monitoring, analysis and assessment should precede planned use and accompany actual use of wild living resources. The results should be made available promptly for critical public review.

In the appendices of the workshop report, the following definition of conservation was given:

> Conservation of the living resources of the sea is that aggregate of measures required to maintain those resources and their environment in a state such that
>
> 1. a maximum and stable supply of food and other marine products may be taken from them on a continuing basis;
>
> 2. there is a minimal likelihood of irreversible or long-term adverse effects of exploitation on particular resources or on the marine ecosystem as a whole;
>
> 3. a wide diversity of options for future use is ensured.

This is followed by a statement concerning the manner in which conservation measures should be formulated. That is:

1. avoiding wasteful use of other natural resources expended to secure the supply of food and other marine products;
2. providing a margin of safety to allow for unpredicted variations and characteristics of marine resources and their environment, and for the fact that the application of measures may be subject to delay or be otherwise imperfect;
3. securing in the first place a supply of food for human consumption.

Although the objectives as stated in current LOS documents may not directly influence the character of fisheries science, the intent and manner of defining management goals in these documents and the others referred to could significantly modify the scope and direction of marine science and influence the performance and capacity of science to contribute knowledge important to rational management of the ocean's living resources.

4. THE CONSEQUENCES OF JURISDICTIONAL AND PHILOSOPHICAL CHANGES

It is not my intent to question the desirability of jurisdictional changes which have been proposed at the Law of the Sea Conference or to challenge the need for altering traditional fisheries management goals. Certain changes are inevitable and we must expect that the working environment for fisheries scientists will be sharply altered during the next decade. Our purpose here should be, then, to briefly examine the legal and functional implications of possible changes and, in light of these, determine whether or not ACMRR can in the future play a role in facilitating the conduct of fisheries science on the high seas and in clarifying the role of the fisheries scientist in light of changing resource management goals and philosophies.

The establishment of an international 200 mile economic zone will create a legal regime which perhaps encompasses 95%-98% of the world's fisheries resources now being exploited. The zone will cover the major areas where high seas fisheries are conducted and the area where much fisheries science has been carried out. It seems to make little difference whether or not the language finally adopted by the Conference is that proposed in the Informal Single Negotiating Text of Subcommittees 2 or 3. The legal implications of both either explicitly or implicitly require that scientific investigations of living resources within the proposed economic zone be conducted only with the consent of the coastal state. Hence, the historical legal freedoms associated with science will have departed, particularly as they relate to the fisheries arena. The language of Subcommittee 3 would seem to exempt science directed towards more basic objectives; however, semantics and definitional aspects of the Articles are indeed difficult to interpret and perhaps all of ocean science will operate on a de facto level within a consent regime.

If one examines the functional requirements for clearance, it is quite clear that science will no longer be unbridled. The question which remains is whether or not fisheries science can be conducted in a reasonable fashion and still meet the obligations that relate to a consent regime. The requirements of the proposed consent regime impose certain bureaucratic procedures which in themselves will increase the complexities of planning and programme execution. The lead time to carry out large-scale, high-seas fisheries studies of a unilateral or even cooperative basis may be substantially extended in order to insure all the appropriate clearances have been been achieved. In addition, the planning of fisheries science takes on a different character inasmuch as it must take into consideration the thoughts, wishes, etc., of the coastal state in whose economic zone such research will

be conducted. Planning also must consider the inclusion of scientists from host countries into the activities and insure that they have more than observer status in developing the research plans. Right to publish the results of research activities may also be evaluated by the coastal state or states in whose waters the research is to be conducted. Hence, one must assume that the new environment will require a high degree of formalization and structuring of the science activity.

In many areas of the world, consent may be rather routine without the coastal state requiring that all options placed at its disposal in terms of obligations are met. In other areas, the processes of planning and executing fisheries science may be complex and time consuming. In the design of any large-scale high-seas fisheries activity, planning will have to be geared to the most complex nationally established procedures. This will have to be considered in conceptualizing multi-area or national cooperative studies from the standpoints of the likelihood of obtaining consent to carry them out, the time required for permission, and the complexity of the operational procedures.

Scientific performance may or may not be influenced by the more complicated bureaucratic process. Once clearance has been obtained to operate in a particular area, one might assume the capacity to perform particularly scientific missions would not be changed. This, of course, would depend on the benefits or costs of multiple group planning and whether or not experimental designs evolved by scientists were modified as a price to achieve consent. Performance might also be altered by the fact that governments could not respond quickly enough to insure certain priority multi-national studies were undertaken within the appropriate timeframe. Finally, one must consider that the level of bureaucracy itself in the ocean scientists' arena could have a negative affect in terms of stifling the recruitment of competent individuals to the fishery field.

The impact of changing philosophical bases for fisheries management may be less drastic. Regardless, it still may have an influence on the direction of fisheries science and the perception of the technical basis required for decision making.

There has been some rhetoric that the fisheries biologist has been unable to budge from his support of the hallowed values associated with the maximum sustainable yield concept. In general, however, I do not find this to be the case. There is as much, or more, debate within the biological community concerning the shortcomings of MSY as a management goal as there is concerning goals within other scientific and technical disciplines. The problem does not seem to be as much one of clinging tightly to tradition as it is of questioning the goals proposed to replace MSY, such as optimum yield, optimum sustainable yield, ecological management, etc. The concept of a management goal which allows decision makers to take into account economic and sociological factors is acceptable to most marine biologists and is probably a desirable modification from past goals. Language which would require management decisions to be based on the maximum sustainable yield, taking into account sociological and ecological factors, would not seem to impact directly on the nature of biological studies required of the fisheries scientists.

What appears as a more imposing hurdle is adopting new goals which cannot be quantified and which may have different meanings among nations. In this sense, society as a whole must decide the overall objectives of management of the oceans living resources. The scientist, however, must have some scale to determine what technical inputs are desirable in terms of formulating decisions. These inputs to the decision making process may be reports on the status of stocks, the anticipated surplus production, the population level, the consequences on an entire community of animals of exploiting only one or a few species within it, etc. Hence, unless clarified, the objectives of optimum yield or optimum sustainable yield do not really provide any desirable guidelines; and if they are to be functional, they must be defined in more specific sociological, ecological, and biological terms.

The concept of managing to maintain the "ecological health" of a community is appealing to a large segment of the general public as well as to some scientists. Managing to achieve ecological objectives must ultimately be defined in terms of the dynamic ranges of

population complexes and ecological norm. Such objectives become important only when we have the capacity to verify ecological relationships in a meaningful way. Until such time as this management goal is quantifiable, it will not provide any real guidance or direction to the fisheries scientists. Quite the opposite, it may result in a diffusion of effort without any real focus in terms of desirable outputs for managers.

If the cost of generating such information is exhorbitant in terms of society's willingness to pay, fisheries science will have to retrench into more simplistic approaches and assume that the interactions of animal assemblages culminate in certain surpluses being produced on an average for individual species or species groups.

The fisheries scientist can best serve society by establishing a clearer understanding of the types of biological information which can realistically be acquired and which is important to the decision processes, regardless of the scope and character of goals which are associated with human values. For better or worse, the fishery biologist must assume there will be a broadening of inputs into decision making and a demand for biological data which has not traditionally been available to decision makers.

5. SUMMARY AND CONCLUSIONS

It seems clear that jurisdictional changes are likely to have a substantial impact on the conduct of fisheries science over the next several decades. Because a new philosophy of fisheries management is now emerging based upon both old and new concepts and goals, it seems appropriate that ACMRR in its discussions evaluate two basic questions: (1) Can ACMRR as an organization or through its interrelations with other organizations propose procedures which will minimize the impediments to the conduct of fisheries science? and (2) Should ACMRR as a group or through one of its working parties evaluate the concepts of new definitions and objectives that are being proposed for the management of ocean living resources? From the author's point of view, ACMRR should be responsive in an affirmative manner to both questions.

6. REFERENCES

Alverson, D.L., Management of the ocean's living resources: a book review and perspective (in press)

American Society of International Law, A report of the Working Group on Living Marine 1974 Resources. Principles for a global fisheries management regime. Washington, D.C., ASIL

Roedel, P.M. (Ed.), Optimum sustainable yield as a concept in fisheries management. 1975 Spec.Publ.Am.Fish.Soc., (9)

Zuckerman, Sir S., Scientists in the arena. In Proceedings of decision making in 1974 ? national science policy, Edinburgh, edited by the CIBA Foundation. J. & A. Churchill, Ltd.

SOME ASPECTS OF FISHING PATTERNS IN RELATION TO FISHERY MANAGEMENT

by

Ø. Ulltang
Institute of Marine Research
Bergen, Norway

CONTENTS

		Page
1.	INTRODUCTION	54
2.	GROWTH AND RECRUITMENT OVERFISHING	54
3.	THE "MAXIMUM SUSTAINABLE YIELD (MSY)" CONCEPT	55
4.	SPECIAL ASSESSMENT AND MANAGEMENT PROBLEMS CREATED BY FISHING PATTERNS WITH A HEAVY YOUNG FISH FISHERY	56
5.	CONTROL OF FISHING PATTERN BY MANAGEMENT	57
	5.1 Separate quotas on young fish and minimum legal size regulation	57
	5.2 Mesh size regulations combined with a total allowable catch	57
	5.3 The effect on fishing patterns of greatly varying recruit-classes	62
6.	REFERENCES	67

1. INTRODUCTION

The development in fishing gears and fish detecting equipment during the last one or two decades and the far distant fleets ability to seek out the best fish concentrations have in many cases lead to important changes in fishing patterns. Extension of the seasons and areas fished have increased the fishing pressure on many fish stocks, and the pressure may have increased especially on certain components of the stocks which in earlier years were exploited only lightly. A stock which traditionally was fished mainly during the spawning season may for example be fished more heavily during the whole year over its whole distribution area, one of the consequences often being that much more young (immature) fish are caught.

A heavy fishery on immature fish is a common factor for many stocks which are over-exploited or, in the worst cases, fished down to almost complete extinction. In this paper fishery management is discussed especially in relation to those aspects of fishing pattern which imply heavy fishing on young (immature) fish. The discussion will be on a "one species basis", and the important problems in management connected with mixed fisheries and species interactions will thus not be dealt with.

2. GROWTH AND RECRUITMENT OVERFISHING

A heavy fishery on young (immature) fish will in most cases lead to a lower yield per recruit value than the maximum obtainable one, and in all cases to a strong decrease in the spawning stock per recruit (fishing on juveniles will reduce the spawning stock per recruit by the factor $\exp(-\sum_i F_i)$ where i is summed over the juvenile age-groups). The effect on the total long term sustainable yield will be the combined effect of the changes in yield per recruit and possible changes in recruitment level caused by changes in the size of the spawning stock biomass.

Cushing (1972) distinguished "growth overfishing" from "recruitment overfishing". In the first, yield per recruit is reduced by too much fishing, but recruitment is not affected. In the second recruitment is affected as a result of a too low spawning stock.

Growth overfishing results in a lower long-term sustainable yield than the maximum obtainable one. Also the catch per unit of effort will be reduced, and in addition the annual variation in yield will be higher than if the stock size was kept at a higher level because the catch will depend strongly on the strength of a few year-classes.

Recruitment overfishing may very rapidly cause total collapse in stock because a reduced recruitment will cause a further decline in the spawning stock if management actions are not taken immediately.

A heavy young fish fishery will usually result in growth overfishing and in addition increase the danger for recruitment overfishing. Once it is observed that the spawning stock is too low to produce a year-class of normal strength, it may be too late to take management actions, particularly in a situation where there is heavy fishing on immature fish. This was illustrated by the collapse of the Atlanto-Scandian herring stock. In 1969-1970 it became clear that the spawning stock was reduced to an alarmingly low level. Cohort analysis shows that the main reason for the strong reduction in the stock was the heavy fishery on immature herring in the late 1960's which completely stopped the recruitment to the spawning stock (Dragesund and Ulltang, 1975). When the very low level of the spawning stock was observed in 1969-1970 the collapse was a reality because there was almost no immature herring left which could build up the spawning stock in the coming years. Suddenly one was in a situation where there was no spawning stock to produce recruits, and no immatures to build up the spawning stock. (The situation could have been a little improved if there had been a complete stop in the young herring fisheries from 1969 onward which would have saved more of the not too poor 1969 year-class.)

3. THE "MAXIMUM SUSTAINABLE YIELD (MSY)" CONCEPT

Before embarking on the particular problems of fishing patterns in relation to management the author would like to briefly discuss the MSY-concept because of its broad usage and key position in management context.

It has become common in international fishery regulations to agree on total allowable catches corresponding to the level of fishing mortality giving the "maximum sustainable yield". In the way "MSY" in most situations has been calculated it is the yield corresponding to the fishing mortality "F_{MSY}" which gives the maximum yield per recruit under the existing selection pattern or age of first capture. This "MSY"-level of fishing does not necessarily give the maximum obtainable long-term yield from the stock. Firstly, if the selection pattern or age of first capture is changed, "MSY" may change (and also the "F_{MSY}"). Secondly, it may well happen that a "F_{MSY}" causes decrease in recruitment (and therefore in yield) through a too low spawning stock, especially if the given selection pattern or age of first capture implies that a lot of immature fish are caught. This may in the worst cases cause total collapse in the stock. Thirdly, the yield a stock is able to maintain may be dependent on environmental conditions and the state of other stocks and therefore may vary from one time period to another.

For the reasons given above the traditional "MSY"-level of fishing does not necessarily ensure neither a maximum nor a sustainable yield. The "MSY"-concept in the way it has been used has caused a lot of confusion, and it should therefore either be clearly redefined or not used at all.

Because of lack of knowledge about the recruitment mechanism the fishing strategy which gives the maximum long-term yield is not known for most of the fish stocks. This does not mean that nothing can be done in order to maximize the yield. If one:

(a) minimizes the catch of fish below a certain size in order to take care of the growth potential of fish,

(b) applies a fishing mortality F which on average is not higher than the F which gives maximum yield per recruit, but which gives a yield per recruit value near the maximum one, for example $F_{0.1}$ (ICNAF, 1972),

(c) puts a lower limit on the size of the spawning stock in order to secure future recruitment, basing the choice of limit on historical records of spawning stock size and recruitment,

one would in most cases probably arrive at a fishing strategy giving a long term yield near the maximum obtainable one. Setting the constraint (c) means that in some years, the F may have to be set below the F-value arrived at under (b), while in other years a higher F may be applied, the actual F being chosen by looking both at stock size and age composition of the stock. The age composition is of importance for utilizing the growth potential. If one or several strong year-classes are recruited to the stock, giving a stock size well above the limit set by (c), one could profitably fish with a higher F than the value arrived at by (b) when the strong year-classes have nearly reached their maximum biomass.

In addition to the constraint set by (c) one could also put an upper limit on the stock size in order to avoid reduced growth or increased natural mortality as a result of a too high stock size. The strongly reduced growth observed on the capelin in the Barents Sea in 1974-1975 was probably the result of extraordinary strong year-classes recruiting the stock (Anon., 1975c). The capelin has been exploited to a rather high extent since 1970, but the main fishery has been on the prespawning and spawning capelin and thus has not significantly reduced year-class strength in the immature part of the stock.

4. SPECIAL ASSESSMENT AND MANAGEMENT PROBLEMS CREATED BY FISHING PATTERNS WITH A HEAVY YOUNG FISH FISHERY

When a stock is fished down through "growth overfishing" a bigger part of the fishing effort inevitably will concentrate on younger year-classes (for the simple reason that there are few old fish) if it is not prevented from doing so. The scientists recommendations on total allowable catch will strongly depend on:

(a) their estimates of the strength of the younger year-classes,

(b) their opinion on how big the spawning stock should be, i.e. how large quantities of fish should be allowed to survive to maturity, in order to secure future recruitment.

Generally the estimates of the strength of the younger year-classes have very wide confidence limits and often they are nothing more than assumptions or guesses. The ability of fishing fleets to concentrate their fishing on young recruiting fish often leads to a situation where the catch of a certain young year-class is higher than may have been expected. One has, however, no means to decide whether the reason for this is that the year-class is stronger than expected or that the fishing mortality is especially high on this year-class as a result of the fishing pattern. This is especially a problem in many pelagic fisheries. Typical examples will be found in the assessments of the mackerel stocks in the Northwest Atlantic (ICNAF, 1974, 1975) and of the North Sea herring in the Northeast Atlantic (Anon., 1974, 1975a). At the time good estimates of year-class strength are available very little may be left of the year-class in question. The situation may be somewhat better in demersal fisheries, but also here changes in fishing pattern through aimed trawling with midwater trawls may make it difficult to get estimates of the strength of the younger year-classes from the catch composition only (Anon., 1975b).

With a low age of first capture and a relatively high maturity age the spawning stock may be reduced below the critical level where recruitment is affected even with moderate annual fishing mortalities. The scientists advice on total allowable catch will of course have to depend strongly on what is regarded as a critical level for the size of the spawning stock. This problem will not exist to the same extent if there is no, or only a small, fishery on immature fish because the spawning stock will then be maintained at a much higher level.

It has proved to be difficult in for example the two fishery commissions for the northern Atlantic, ICNAF and NEAFC, to get agreement on catch quotas based on conservative estimates of strength of the younger year-classes and a precautionary approach with respect to the critical level for the size of the spawning stock. Such quotas would often imply a temporary drastic cut back in catch without the managers knowing for sure that this is necessary.

Improvements in science which would enable firmer estimates on:

(a) the strength of younger year-classes,

(b) the quantities which should be allowed to survive to maturity in order to secure future recruitment,

would without doubt lead to more timely and appropriate management. Until such progress is made fishing of immature fish generally should be kept on a minimum or moderate level. In addition to (in most cases) an increase in yield per recruit this would ensure that better estimates of year-class strength were available before a year-class was fished in big quantities and that the size of the spawning stock in most cases would be above the critical level where there is real danger for recruitment failure.

5. CONTROL OF FISHING PATTERN BY MANAGEMENT

5.1 Separate quotas on young fish and minimum legal size regulations

Where young and older fish are separated in area or depth or are schooling separately the young fish fishery may be restricted through separate quotas on young fish and/or minimum legal size regulations (zero quota on fish below a certain size). Such regulations make it possible to directly control the fishing mortality on young and older fish separately and may therefore be regarded as the best way of regulating a fishery whenever practicable.

5.2 Mesh size regulations combined with a total allowable catch

Mesh size regulations increase the first age of capture and decrease the fishing mortality on the youngest age-groups in the catch. In assessing the effect of mesh size regulations the possibility that a change in mesh size will influence the fishing pattern is usually not taken into account. Such an influence will generally increase the effect of a change in mesh size. This is illustrated by the very simplified example given below.

Assume one is fishing on a stock where:

(i) Weights at age are equal to those for Arcto-Norwegian cod (Anon., 1973)

(ii) Natural mortality (M) = 0.2

(iii) Age of first spawning = 8 years

(iv) All fish younger than 8 years old are in an area A and all fish 8 years old and older are in an area B (separate from area A).

In Figure 1 are given the yield per recruit and spawning stock per recruit for three different mesh selection alternatives assuming the same fishing mortality in the two areas A and B. The three mesh selection alternatives are as follows (F_i = fishing mortality on age-group i):

Selection a): $F_{i<3} = 0$ $F_3 = 0.3F$ $F_4 = 0.6F$ $F_5 = 0.9F$ $F_{i>5} = F$

Selection b): $F_{i<4} = 0$ $F_4 = 0.3F$ $F_5 = 0.6F$ $F_6 = 0.9F$ $F_{i>6} = F$

Selection c): $F_{i<5} = 0$ $F_5 = 0.3F$ $F_6 = 0.6F$ $F_7 = 0.9F$ $F_{i>7} = F$

The curves are also given for the situation where there is no fishing in area A.

If a total fishing effort E_T is applied on this stock, split on E_A in area A and E_B in area B, and the relationship

$$F = q\,E \quad (F = \text{fishing mortality}, \; q = \text{catchability coefficient})$$

is assumed to be valid in both area A and area B separately, a high fishing mortality in area A will imply a low fishing mortality in area B, and vice versa. We have:

$$E_T = E_A + E_B = \frac{F_A}{q_A} + \frac{F_B}{q_B} \quad \text{, i.e.}$$

$$F_B = q_B\,E_T - \frac{q_B}{q_A}\,F_A$$

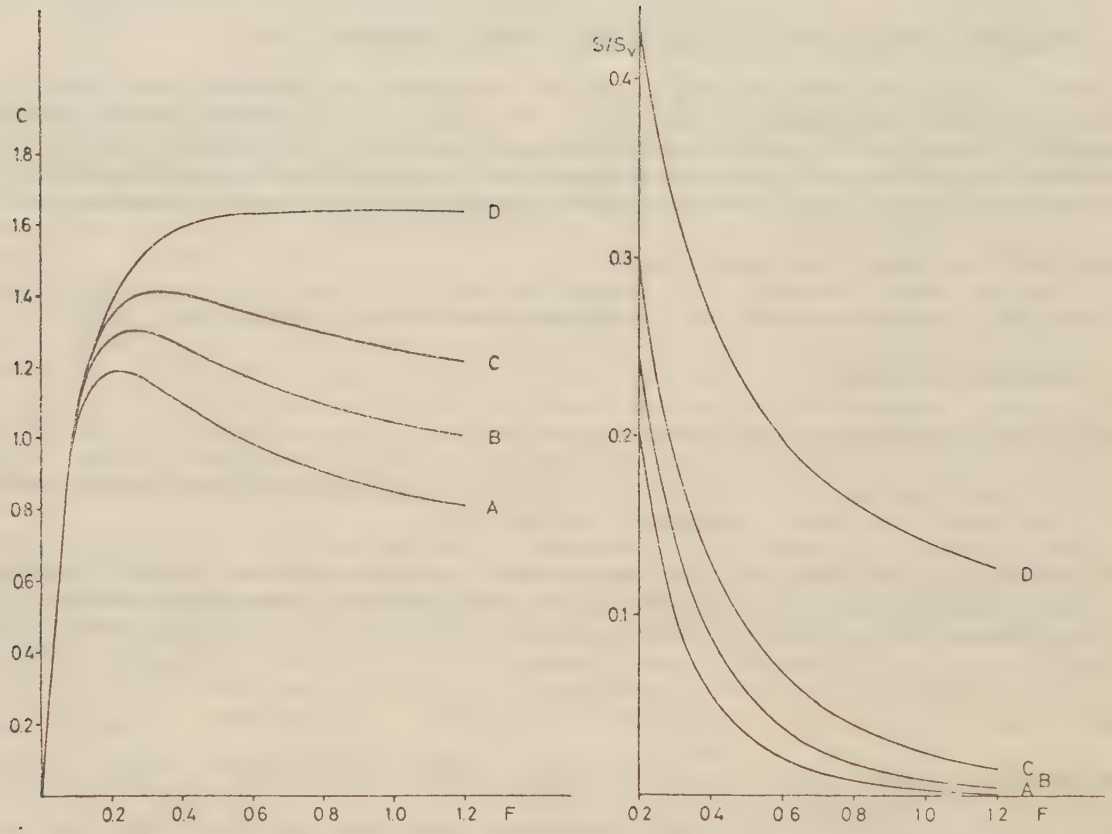


Fig. 1. Yield per recruit (C) and spawning stock per recruit (S/S_V where S_V = spawning stock per recruit in unexploited stock) against fishing mortality (F).

A: Mesh selection a)
B: Mesh selection b)
C: Mesh selection c)
D: No fishing in area A

For further explanation see text.

The catch per unit of effort in the two areas is given by

$$(C/E)_A = \frac{q_A}{F_A} C_A$$

$$(C/E)_B = \frac{q_B}{F_B} C_B$$

In Figure 2 are shown for the three different mesh selections the yield per recruit in area A, area B and the total area together with the catch per unit of effort (per recruit) when

$$q_A = q_B = 1.2 \text{ and } E_T = 0.5, \text{ i.e.}$$

$$F_B = 0.6 - F_A$$

In the calculations it was assumed that a certain combination of F_A and F_B had been applied for a period sufficiently long for establishing an equilibrium situation.

For mesh selection a) the catch per unit of effort is higher in area A than in area B when $F_A < 0.51$ (i.e. $F_B > 0.09$). When $F_A > 0.51$ (i.e. $F_B < 0.09$) the catch per unit of effort is higher in area B. If it is assumed that the effort will go to the area with the highest catch per unit of effort, this will tend to establish an equilibrium situation at the point where $(C/E)_A = (C/E)_B$, i.e. $F_A = 0.51$, $F_B = 0.09$. The yield per recruit would then be 0.94.

If the mesh size is changed to alternative b) the catch per unit of effort in area A will decrease relative to area B. The equilibrium point where $(C/E)_A = (C/E)_B$ would in this case be at $F_A = 0.26$, $F_B = 0.34$. If F_A and F_B did not change, an increase in mesh size from a) to b) would give an increase in yield per recruit from 0.94 to 1.05 only. If in addition the fishing pattern is changed to the situation where $F_A = 0.26$, $F_B = 0.34$ as a result of the change in mesh size, the yield per recruit would increase to 1.33.

If the mesh size is changed to alternative c) the catch per unit of effort will be higher in area B than in area A for all possible combinations of F_A and F_B, i.e. all the effort would tend to go to area B, resulting in $F_B = 0.6$, $F_A = 0$, and a yield per recruit value of 1.63. Again, if the change in fishing pattern resulting from an increase in mesh size from b) to c) had not been taken into account, the estimated effect of the mesh size change would be an increase in yield per recruit from 1.33 to 1.44.

In Table 1 yield per recruit and spawning stock per recruit values are given for equilibrium situations estimated as above for four different sets of values of the parameters q_A, q_B and E_T. If $q_A = q_B = 1.2$ (as in Figure 2) but $E_T = 1$, i.e.

$$F_B = 1.2 - F_A$$

all effort will be in area A for mesh selection a) creating a fishing mortality of 1.2. If mesh size is changed to alternative b) all effort still will be in area A, but there will be some increase in yield and spawning stock per recruit as a result of the mesh size change. If mesh size is increased to alternative c) some effort will be diverted to area B, but most of it will still be in area A. The situation must be characterized as highly unsatisfactory for all three mesh selection alternatives, and it illustrates a point made in an earlier section in this paper: In a "growth overfishing" situation created by too heavy fishing, effort inevitably will tend to concentrate on the younger year-classes because of lack of old fish. In the case illustrated in the upper part of Table 1 ($E_T = 1$) the total fishing effort is so high that a moderate increase in mesh size from a) to b) will not increase the spawning stock size (the stock in area B) to the extent necessary to make the catch per unit of effort of mature fish higher than the catch per unit of effort in the young fish area, and all effort therefore still will concentrate on the recruiting year-classes. If the total effort is cut down to half ($E = 0.5$) a change in mesh size from a) to b) will have a significant effect on the fishing pattern as illustrated in Figure 2 and Table 1.

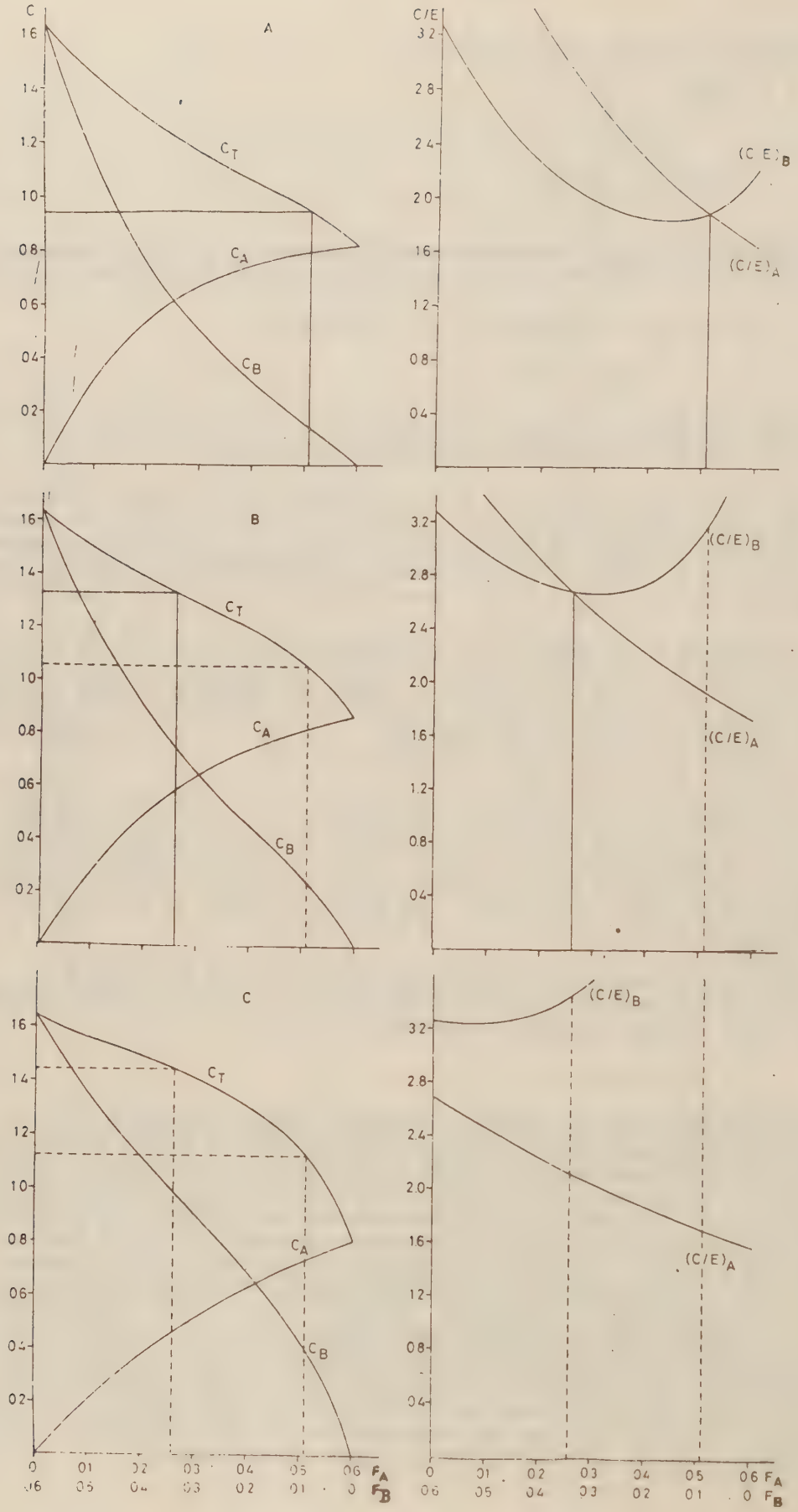


Fig. 2. Yield per recruit and catch per unit of effort (per recruit) for different combinations of fishing mortalities in area A (F_A) and area B (F_B) for mesh selection a (A), b (B) and c (C) when $F_A + F_B = 0.6$.

C_A, C_B and C_T: The yield in area A, area B and the total area respectively.

$(C/E)_A$ and $(C/E)_B$: The catch per unit of effort in area A and area B. For further explanation see text.

Table 1. Equilibrium situations for different combinations of catchability coefficients, total effort and mesh selection pattern

C_{max} = maximum sustainable catch when all effort is in area B.

S = spawning biomass per recruit.

S_v = spawning biomass per recruit in unexploited stock. For further explanation see text.

q_A	q_B	E_T	Selection	E_A	E_B	F_A	F_B	C_A 1/	C_B 1/	C_T 1/	$(C/E)_A$ 1/	$(C/E)_B$ 1/	C_T/C_{max} 1/	S/S_v 1/
1.2	1.2	1	a	1	0	1.2	0	0.79	0	0.79	0.79	0.22	0.482	0.010
			b	1	0	1.2	0	0.95	0	0.95	0.95	0.75	0.579	0.035
			c	0.775	0.225	0.93	0.27	0.96(1.03)	0.28(0)	1.24(1.03)	1.24(1.03)	1.24(2.49)	0.756(0.628)	0.065(0.115)
		0.5	a	0.425	0.075	0.51	0.09	0.80	0.14	0.94	1.87	1.87	0.573	0.090
			b	0.217	0.283	0.26	0.34	0.58(0.82)	0.75(0.23)	1.33(1.05)	2.67(1.92)	2.67(3.12)	0.811(0.640)	0.144(0.148)
			c	0	0.5	0	0.6	0 (0.73)	1.63(0.39)	1.63(1.12)	2.68(1.71)	3.26(5.20)	1.0 (0.683)	0.199(0.251)
0.6	1.2	1	a	0.708	0.292	0.425	0.35	0.76	0.31	1.07	1.07	1.07	0.652	0.058
			b	0.383	0.617	0.23	0.74	0.54(0.76)	0.85(0.48)	1.39(1.24)	1.39(1.08)	1.39(1.65)	0.848(0.756)	0.089(0.090)
			c	0	1	0	1.2	0 (0.65)	1.64(0.73)	1.64(1.38)	1.34(0.92)	1.64(2.50)	1.0 (0.841)	0.127(0.136)
		0.5	a	0	0.5	0	0.6	0	1.63	1.63	2.42	3.26	1.0	0.199
			b	0	0.5	0	0.6	0	1.63	1.63	1.94	3.26	1.0	0.199
			c	0	0.5	0	0.6	0	1.63	1.63	1.34	3.26	1.0	0.199

1/ Figures in bracket refer to a situation where fishing pattern does not change when selection is changed from a) to b) or c), i.e. E_A and E_B for selection b) and c) are equal to E_A and E_B for selection a).

In the lower part of Table 1 the catchability coefficient in area A is assumed to be 0.6, i.e. half that assumed in the upper part of the table giving

$$F_B = 1.2 - 2 F_A$$

and

$$F_B = 0.6 - 2 F_A$$

for $E_T = 1$ and $E_T = 0.5$ respectively. The lower catchability coefficient in area A will have the effect of diverting more effort to area B. The mesh selection alternative b) will here be quite satisfactory even if total effort is set equal to 1 (it would of course be desirable to have a lower fishing mortality than 0.74 in area B, see Figure 1). The table illustrates how a quite satisfactory situation may be turned to a highly unsatisfactory one if there is an increase in efficiency in the young fish fisheries. This could for instance be brought about by the intorduction of pelagic trawls on off-bottom concentrations of young fish. A doubling in efficiency would mean to move from a situation in the lower part of the table to the parallel one in the upper part.

5.3 The effect on fishing patterns of greatly varying recruit-classes

The per recruit study illustrates how mesh size regulations and limitations on total effort (for example by a total quota) may change the fishing pattern. The main weakness with such studies is that changes in fishing pattern created by variations in year-class strength are not taken into account. If a year-class of many times "normal" strength recruits to the fishery, the fishing fleet will concentrate on this year-class (if it is possible) as long as it is a dominating one. This may to some degree decrease the effects of mesh size regulations as illustrated in the following example:

Suppose a year-class of 10 times normal strength recruits to the population used in the per recruit study and that $q_A = q_B = 1.2$ and $E_T = 0.5$ (as in Figure 2). For selection a) the year-class starts recruiting the fishery as three years old. There will then be a big increase in catch per unit of effort in area A which tends to draw all effort to this area, i.e. $F_A = 0.6$ and $F_B = 0$ (Figure 3). For selection b) the same will happen at an age of four years old. For both selections all effort will be in area A until the year-class is eight years old. Then all effort, following the year-class, is diverted to area B. In Figure 4 the biomass in area A and area B is plotted against age of the strong year-class. For selection a) so little is left of the year-class at nine years of age that most of the effort will go back to area A. For selection b) no effort will go back to area A before the year-class is ten years old, and then only half of the effort will go back to that area. For both selections the fishing pattern will now gradually approach the equilibrium situation i.e. $F_A = 0.51$, $F_B = 0.09$ for selection a) and $F_A = 0.26$, $F_B = 0.34$ for selection b). In Figure 5 is plotted the catch and the accumulated catch from the year when the year-class is three years old until it is 10 years old. In this period the accumulated catch is about 25 percent higher for selection b) than for selection a) while in the equilibrium situation (yield per recruit) the difference would be about 41 percent. The spawning stock (S_B in Figure 4) at the time the year-class becomes mature (eight years old) would be about 92 percent higher for selection b) than for selection a).

In Figure 6 is plotted the catch per unit of effort. Because effort is the same for the two alternatives the relative difference in catch per unit of effort will be equal to the difference in catch.

In Figures 3 to 6 are also illustrated two alternative strategies having mesh selection b). In alternative I it is assumed that by separate quotas in areas A and B the fishing mortalities are all the time kept at the equilibrium point, i.e. $F_A = 0.26$ and $F_B = 0.34$. If it is not possible for practical reasons to have separate quotas in the two areas, one solution could be to set the total quotas so low that F_A is kept well below 0.6

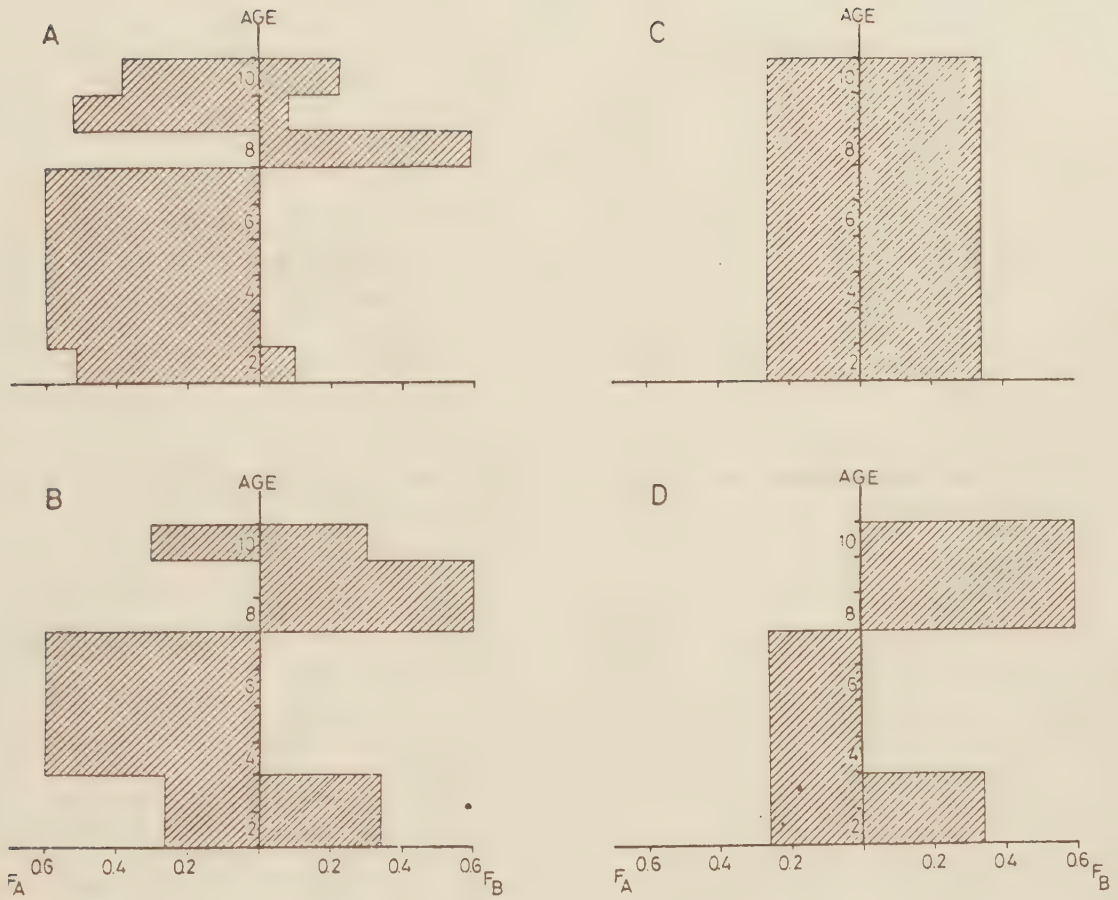


Fig. 3. Fishing mortality in area A (F_A) and area B (F_B) at different ages of strong year-class.

A and B: Mesh selection a) and b) respectively, $F_A + F_B = 0.6$ and fishing effort goes to the area with highest catch per unit of effort.

C and D: Alternative strategies I and II respectively. For further explanation see text.

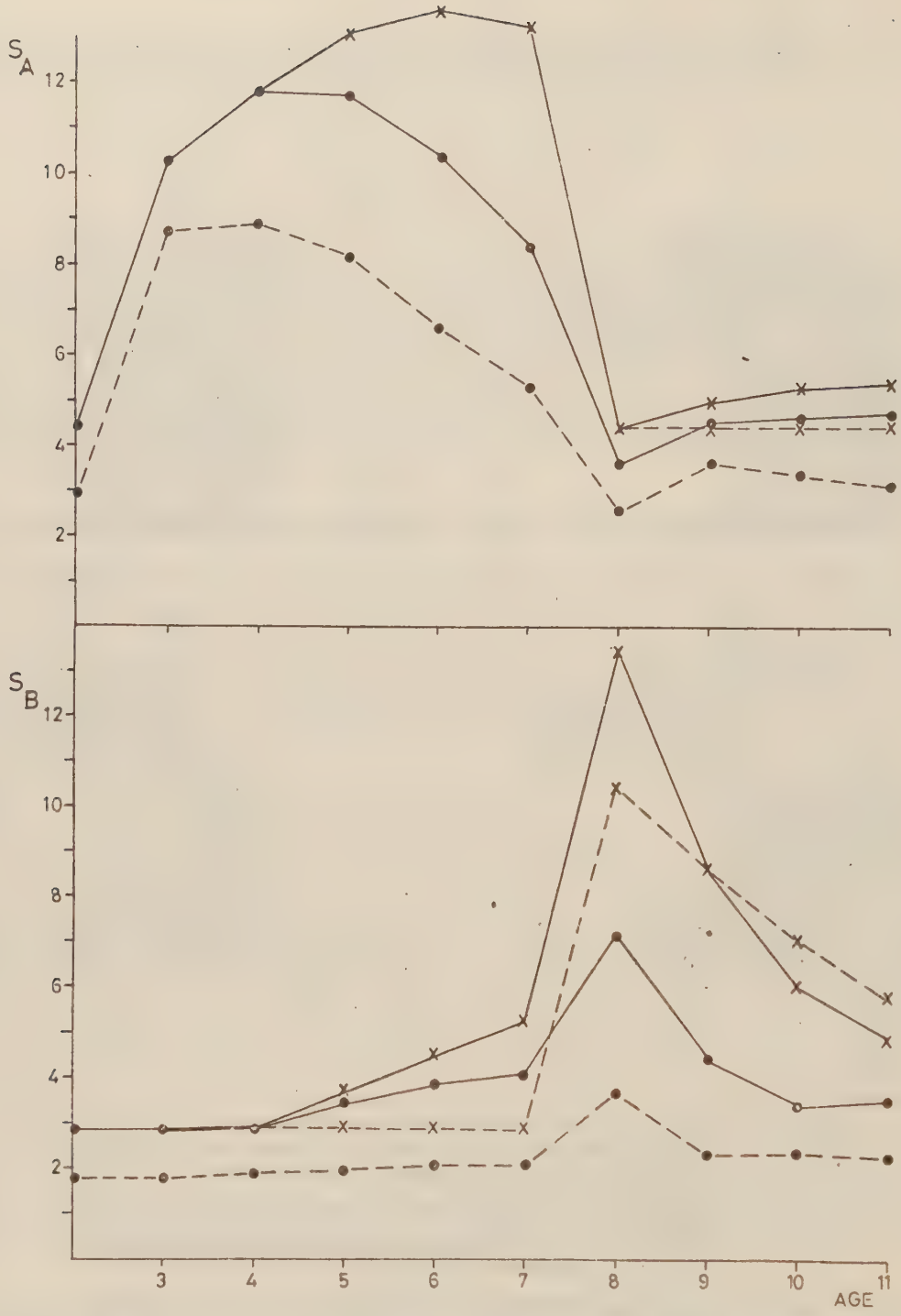


Fig. 4. Stock biomass in area A (3 to 7 years old fish) and area B

•— —•— —• and •———•——— • Mesh selection a) and b) respectively, $F_A + F_B = 0.6$ and fishing effort goes to the area with the highest catch per effort.

×- - -×- - -× Alternative strategy I

×———×——— × Alternative strategy II

For further explanation see text.

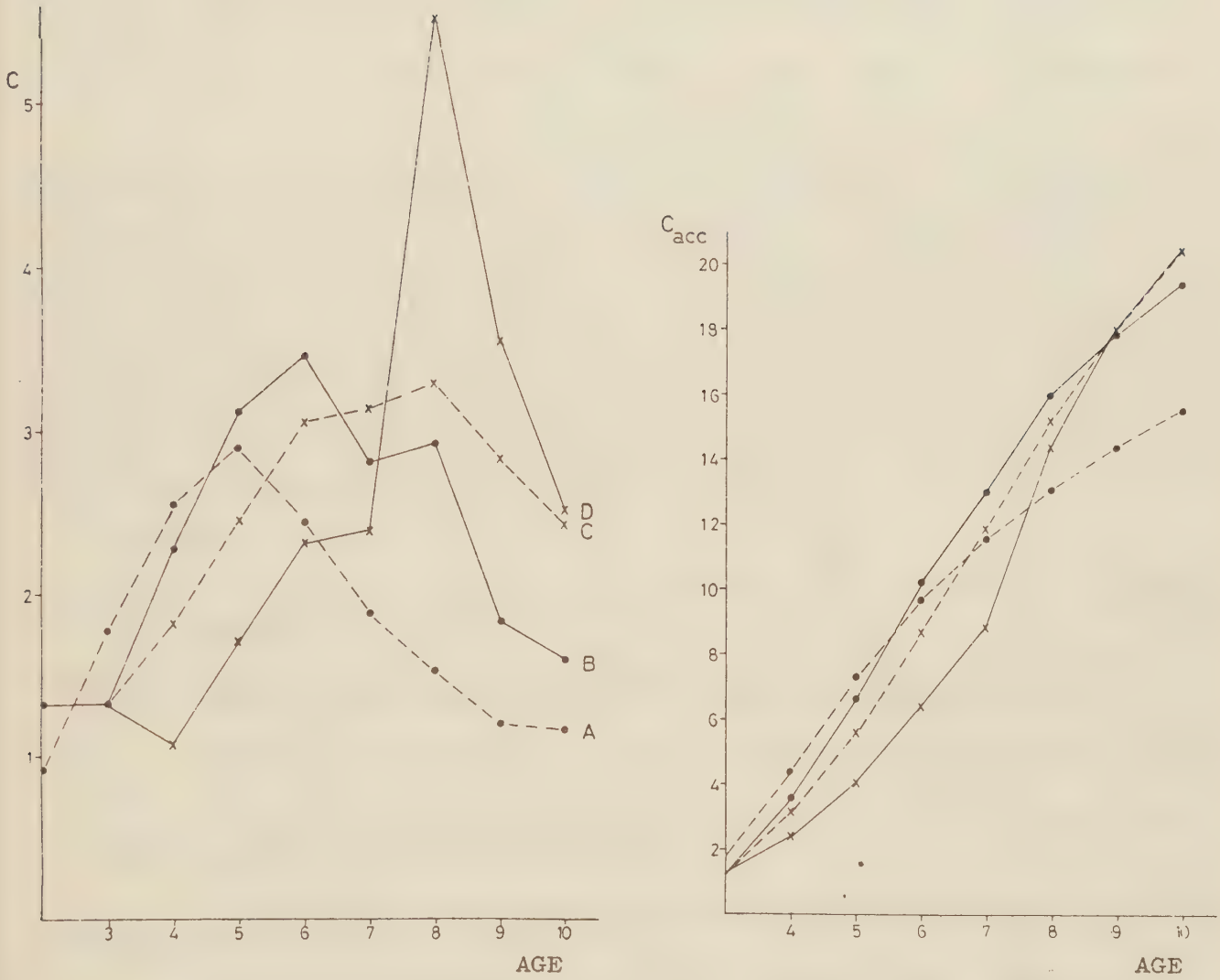


Fig. 5. Total catches (C) and accumulated total catches (C_{acc}) against age of strong year-class. Symbols as in Fig. 4.

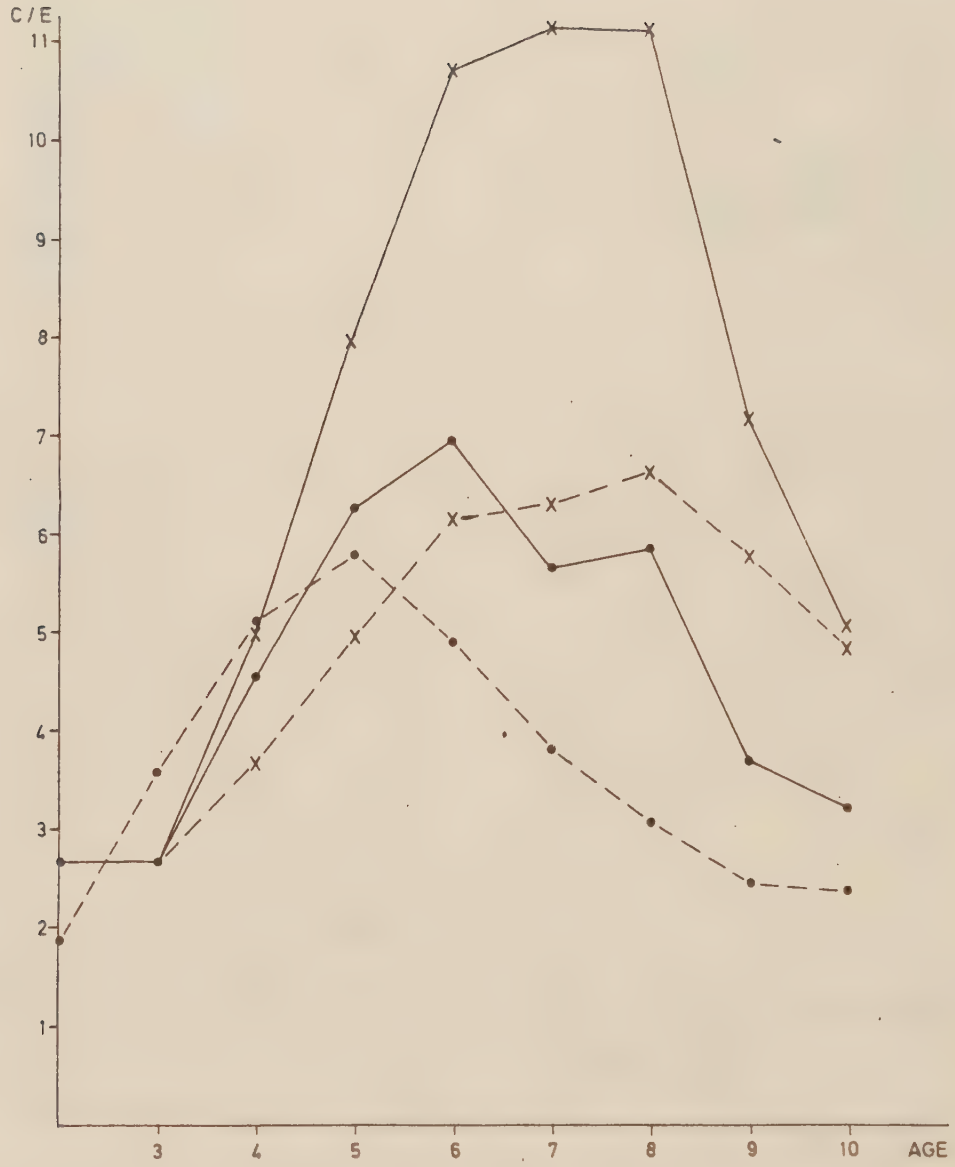


Fig. 6. Catch per unit of effort against age of strong year-class. Symbols as in Fig. 4.

the years when all effort will be diverted to area A, but allow an $F_B = 0.6$ when the year-class has recruited the spawning stock. This is illustrated as alternative II in Figures 3 to 6, assuming a total quota equal to the catch corresponding to $F_A = 0.26$ during the years when the strong year-class is four to seven years old. This implies no fishing on eight years old and older fish during those years. Both these strategies gives a little higher accumulated catch (Figure 5) over the period than fishing with the same mesh size but with no additional regulations. In addition the stock size at the end of the period is higher (Figure 4) which means higher catches also in the first coming years. Alternative II gives the highest catch per unit of effort of all strategies studied as would be expected when reducing the effort for some years.

The strategy giving maximum long-term yield (in weight) would be not to fish in area A at all.

It should again be stressed that the example given above is very simplified. Especially the factors determining distribution of effort will be more complex in real situations. The example illustrates, however, that a mesh size which in an equilibrium situation protects young fish to a satisfactory extent will not necessarily do so when an outstanding year-class is recruited and the fishing pattern changes with the relative abundance of young and old fish. It should be noted that a similar change in fishing effort from old to young fish as illustrated above also would take place if the stock of old fish for some reason has become exceptionally low and year-classes of normal strength recruit to the stock of young fish. In situations where mesh size regulations do not have the desired effect, relevant additional regulatory measures would be to set separate quotas on young and old fish or, if this is not possible for practical reasons, to set the total quota low enough to ensure that even if all the quota is taken as young fish the fishing mortality on this component will be kept at a relatively low level. The temporary decrease in yield by such a strategy may then be more than counterbalanced by increased yield in future years.

6. REFERENCES

Cushing, D.H., 1972 A history of some of the international fisheries commissions. Proc.R.Soc. Edinb.(B), 73:361-90

Dragesund, O. and Ø. Ulltang, 1975 Stock size fluctuations and rate of exploitation of the Norwegian spring spawning herring 1950-1974. ICES.C.M. 1975 (in press)

ICES, 1973 Report of the North-East Arctic Fisheries Working Group. ICES.C.M. 1973 (F:3): 39 p. (mimeo)

_____, 1974 Report of the Herring Assessment Working Group for the Area South of 62°N. ICES.C.M. 1974 (H:4):35 p. (mimeo)

_____, 1975 Report of the Herring Assessment Working Group for the Area South of 62°N. ICES.C.M. 1975 (H:2):39 p. (mimeo)

_____, 1975a Report of the North-East Arctic Fisheries Working Group. ICES.C.M. 1975 (F:6):23 p. (mimeo)

ICNAF, 1972 Redbook, 1972. Redb.ICNAF, (1972)Pt.1:87 p.

_____, 1974 Redbook, 1974. Redb.ICNAF, (1974):154 p.

_____, 1975 Report of Assessment Subcommittee. Ser.Pap.ICNAF, (3498):43 p. Addendum 1: 1-7

Anon., 1975 Ressursoversikt for 1975. Fisken og Havet., 1975 (Saernummer):129 p.

MANAGEMENT OF COASTAL FISHERY RESOURCES UNDER THE NEW REGIME

by

H.A. Larkins
International Fisheries Research
Northwest Fisheries Center
National Marine Fisheries Service
Seattle, Washington, U.S.A.

CONTENTS

		Page
1.	INTRODUCTION	70
2.	MANAGEMENT PHILOSOPHY	70
3.	SHORT-TERM REQUIREMENTS	72
4.	LONG-TERM REQUIREMENTS	73
5.	IMPLEMENTATION	73
6.	ORDERLY TRANSITION	74

1. INTRODUCTION

The rather sorry history of fishery management around the world can be largely attributed to the fact that agencies with management responsibilities did not have complete, legal jurisdiction over the resources they professed to manage or, conversely, international organizations whose collective jurisdiction was broad enough to cover a particular resource did not have sufficient authority to perform real management. For example, the management programme of a coastal country could be applied only within the narrow zone of jurisdiction off its coast or only to its citizens beyond that zone - compliance by other nationals was strictly voluntary. On the other hand, large multi-national compacts were too often composed of parties with diverse interests which precluded the consensus usually required for implementing an effective management scheme.

2. MANAGEMENT PHILOSOPHY

Under an internationally accepted, extended jurisdiction regime these hinderances to management of coastal-type fishery resources should largely disappear - most of those resources will be clearly within the jurisdictions of coastal countries. The use of "jurisdiction" in the plural is advised inasmuch as in many, if not most, areas of the world the idiosyncrasies of geography and fish distribution will be such that major coastal fish stocks and the fisheries on them will range across the boundaries of individual national zones of jurisdiction. In those cases effective management will occur only through an appropriate pooling of national jurisdictions, management objectives, and regulatory schemes - in other words, reliance upon regional organizations will be absolutely essential for the implementation of rational fishery management.

The nature of these regional organizations undoubtedly will differ from those of the past in that they will be made up of and most directly controlled by coalitions of coastal countries whose interests are likely to be more alike than was the case with prior international organizations to which both coastal and distant water fishing nations were party and had equal voice. Therefore, control, if not outright "ownership" of coastal resources by the adjacent coastal state or states should bring into line, for the first time in many instances, management authority and resource jurisdiction - that is, a national or regional management entity will have virtual jurisdiction over the resources it intends to manage.

Accordingly, the opportunity for interplay between biological, economical, and social factors should be enhanced - from the point of view of the coastal nation(s) - because they will then be able to decide whether it is in their best parochial interest to produce protein for domestic consumption, maximize financial return by leasing out fishing rights to others or conducting their own fisheries on the basis of maximum economic yield rather than maximum biological yield, or providing such social benefits as employment, preservation of unique cultures, etc.

One, then, could consider "optimum" yield to be a primary management goal, with the definition of "optimum" left to the managing entity in terms of mixing biological, economic, and social factors as best fits the context of national or regional interests and priorities. The optimum mix of these factors, however, will not be easy and will increase in difficulty as one moves up the scale from local to national to regional to international, simply because political and cultural diversity increases on the same scale. What might be a good mix for one small fishing village might not be the best for a whole coastline, which in turn, may not be best for an entire country or region.

The question of where on this scale to localize the management authority might be answered by keeping in mind two considerations: (1) the optimum mix is easiest to achieve on the most local scale; and (2) for management to work, the management authority must also have jurisdiction over the resources it is to manage. Therefore, a logical principle might be: to vest management authority in the most localized political entity which has jurisdiction over the entirety of the resource to be managed.

A hypothetical example of this principle in action might be drawn from the eastern Bering Sea herring resource (a resource and region that the author is familiar with and which contains a broad spectrum of elements from highly developed distant water fisheries to native subsistence fisheries). At present, the eastern Bering Sea herring stocks are fished primarily by Soviet trawlers and by Japanese trawlers and gillnetters - a very small catch is taken inshore by North American native Eskimos. Because these herring stocks range well offshore beyond the jurisdiction of the State of Alaska, management would be vested in the United States Government (whose jurisdiction would cover most if not all of the eastern Bering Sea herring distribution). Then, the U.S. and the State of Alaska in concert might prioritize their interests in this resource in the following manner: First, protect and enhance the Eskimo culture by providing access to the resource consistent with its artisanal equipment, experience, and need; second, keep open future options for a large-scale U.S. fishery by maintaining the resource at a near-maximum biological level; third, gain whatever economic return possible from the resource consistent with the first two priorities.

The management programme then, would proceed along the following lines. Inasmuch as that stock is believed to be in a somewhat depressed state because of recent over-exploitation, the total allowable catch would be reduced from the current annual levels of 40 000 - 70 000 mt to, perhaps, 30 000 mt per year; 5 000 tons of mature herring would be reserved for Eskimo fishermen during the spring onshore spawning migration and the remaining portion of the allowable catch (25 000 mt) would be made available to distant-water fishing nations on either a royalty basis, in return for resource concessions beyond U.S. jurisdiction, or for concessions in some other economic arena. If, in the future, a domestic demand grows for this resource, the U.S. would still have the option of maintaining the Eskimo fishery at an optimum level and, further, of assessing the relative values of phasing out the distant-water fisheries with attendant loss of revenue or negotiating advantage, against the social and economic factors involved in a new large-scale domestic fishery. In short, this arrangement would have allowed the resource to be brought under immediate management, the "optimum" mix determined for the present, and options preserved for another mix that might be optimum at some time in the future.

The application of this principle would, of course, be tempered by whatever international standards are contained in the UNCLOS Treaty now being negotiated, particularly those provisions dealing with historic fisheries and maximum utilization. In this regard, there is an often expressed reservation about extended jurisdiction that the new regime, especially in its early stages, will cause a greatly reduced yield of marine protein as coastal states exclude foreign fishermen before their own fisheries have the capacity to take the allowable catch, or as the coastal states apply economically or socially related criteria to fisheries management that militates against maximum biological yield.

If the new regime ultimately permits the high degree of coastal state control over fisheries that the current trend in UNCLOS seems to indicate, the chances are that global fish production will decline. Part of that decline could be caused by simple and ill-founded national emotionalism but one would hope for reasonable treaty standards that would prevent a significant portion of the world's fishery potential from being taken out of production. Furthermore, as nation(s) realize that living resources cannot be "banked" for future national development and that financial (or some other) return can be obtained without adversely affecting future national options, there will be a disincentive to letting lay fallow significant portions of the world's fishery resources.

A second cause of production declines will be the actions of coastal nations to rectify past overfishing and allow depleted or partially depleted stocks to recover to levels that will eventually lead to higher sustained production. In this situation the pendulum may well swing to the side where exploitation is dependent upon evidence that such exploitation is sustainable and away from the side of placing no controls on exploitation until overfishing can be documented. In the long term, this atmosphere will be beneficial to the world - in the short term, it could pose a serious impediment to the

highly developed distant-water fisheries and to current world-wide fishery production rates. Again, one would hope that the shift from the exploitation to the conservation mode is tempered with reason, but if one extreme is to prevail for a short time, would it not be best in favour of the latter mode?

In a more philosophical tone, we are considering a shift from "feeding the world from the world ocean to improving the lot of our citizens from our national waters". Once one understands and accepts the concept that coastal fish populations are henceforth national rather than common properties, the question of reduced worldwide fish production becomes similar in character to that of reduced national wheat, timber or oil production - there are global ramifications but it is national business.

In concluding this rather esoteric section, a third cause of decreased fish production may be expected in the wake of national or regional "optimization". Should countries opt for maximum economic yield, total production may be held below MSY to allow higher catch rates; or, should they seek to preserve some particular culture, they may have to reserve, say, 20 000 mt of the allowable catch of some species so that the natives can be assured of taking 2 000 mt by their primitive means.

In each of these cases, there is a substantial potential for reducing yield - whether or how much remains to be seen. Presumably the laws of supply and demand, both national and international, would quickly produce economic (if not political) pressures to maintain or increase production - in fact, under extended jurisdiction, these pressures might quickly grow to the point where the pendulum could swing back in favour of exploitation, in this case because of the profit motive to the coastal rather than the distant-water state.

3. SHORT-TERM REQUIREMENTS

The types of information needed to carry out the management scheme described above are really no different under extended jurisdiction than they were in the past. A difference does lie, however, in the fact that when the coastal state achieves jurisdiction over the coastal fishery resources - and with it the wherewithall to manage - the incentive for collecting appropriate fishery and biological data should be much greater. This added incentive would be due to the realization that the data bank so amassed can be put to sound management use without a great deal of international debate and defense, and because as a condition of continued access by distant-water fishermen, the coastal state may require them to pay some share of the management (data collection) costs.

A further incentive for the compilation of a broad fishery information base should come from the states' new ability to consider ramifications of the fisheries other than those of purely a biological nature; that is, they would be able to justify the compilation and quantification of economic and social data as well as the basic fishery statistics.

Considering now the more traditional fishery data (i.e., that required for conservation purposes), the management entity should have certain general measures available to implement on "day one" of extended jurisdiction. These need not necessarily be complicated or highly sophisticated management programmes but could merely be reasonable estimates of total allowable catch based on the best information currently on hand or the best professional advice available. The initial consideration under extended jurisdiction should be to bring the existing fisheries under some degree of control so that overexploitation or overcapitalization does not become rampant while awaiting "nth degree" precision in population analyses - the management programme can be expanded upon and fine-tuned with time.

Therefore, a first step might be to carefully review the recent history of the ongoing fisheries with a view to determining whether trends in catch or catch rates have been increasing, stable, or decreasing. If the catches have been increasing but no signs

of biological stress have been noted, one might choose to allow continued (but not unbridled) growth in that fishery by simply fixing such growth at some rather low annual rate with attendant monitoring of catches and catch rates so that as the fishery approaches a rational maximum (i.e. "optimum" yield as defined by the managing entity) that fact can be detected and further growth prohibited. On the other hand, if catches have been falling in the face of increased effort, the manager may choose to enforce a moratorium to allow rapid stock rehabilitation to a level where optimum yield is possible; or, he may accept a somewhat longer rehabilitation period by restricting foreign fishing while allowing smaller-scale domestic fisheries to continue. The important thing is to assess, as best he can, the general condition of the stocks and immediately introduce a reasonable degree of control on the total fishery in order to protect future management options.

Once this initial control is established, the manager can then afford the luxury of developing national (regional) priorities with regard to "optimum yield", and refining the initial fishery controls into a more complete management programme consistent with those priorities. It is at this stage - really not much beyond "day two" of extended jurisdiction - where the apparent trends in catch and catch rates that were used to justify the initial controls can be further analyzed and qualified. For instance, were the stable catch rates that were observed in the near-past merely artifacts of improved fishing efficiency when in fact the resources were declining? Were catches increasing because different segments of the fish population were recently taken under exploitation?

This would also be the time to consider initiation of real-time resource assessment activities that would form a firm base for understanding trends, both past and future, in the fishery. These kinds of activities might well keep a managing agency busy for the first 3 to 5 years of extended jurisdiction, hence they might be considered mid-range objectives.

4. LONG-TERM REQUIREMENTS

On a somewhat longer time scale, along with a continual restructuring of the "optimum yield mix", the resource manager should be building his data base and technical expertise to the point where multi-species management concepts are being developed and "optimization" can be applied to entire fisheries rather than to individual species. At this stage of management development, one would be considering such issues as the direct effect on incidentally caught species in a fishery targeting on another species, and the indirect effect of the catch of prey species on important predators.

Finally, at the far end of the time-scale, measured perhaps in decades rather than years, the ultimate goal would be ecosystem management. Optimization of a nation's or region's fisheries will only be fully achievable (regardless of how defined) when the management system is capable of making rational decisions on an ecosystem-wide basis with a full understanding of, and the ability to predict naturally induced changes in productivity and fishery induced changes in the inter-relationships between the various marine species and between the aggregate marine fauna and the environment. A full realization of ecosystem management is probably not possible under jealously guarded national jurisdiction, particularly in regions where naturally occurring ecosystems span several areas of national jurisdiction. However, by the time this degree of sophistication is available on a global basis, one would hope that enough stability had been obtained in the world's fisheries to permit another try at international institutions developed solely for the purpose of further increasing the biological, economic, and social returns from the fisheries.

5. IMPLEMENTATION

Once the initial blush of achievement fades, and the enormity of the responsibilities attendant to extended jurisdiction are more fully contemplated, the fishery manager will be immediately confronted with the realities of implementation. Aside from the suggested,

and to some extent theoretical outline above, where and how does a manager start? This question is often framed in the context of "how can enforcement of the budding management programme be achieved in a suddenly enormous area of fishery jurisdiction?" There are, of course, a number of approaches to fishery enforcement, some dependent on the type of fisheries, some dependent upon monetary and manpower resources of the managing entity, and some dependent upon the type of management measures that are to be implemented. The latter category contains several possibilities for reducing the problem of enforcement to reasonable proportions.

First, the manager might rely heavily on closed area-time strata rather than restrictions on certain types of fishing. If, for example, the manager is concerned with reducing the incidental catch of a particular species in a directed fishery for other species, rather than allowing off-bottom trawling for the target species year-round and then trying to enforce the no-bottom -trawling provision, he might better try to identify specific time-area units in which the incidental species is most available to trawls and prohibit all fishing in that area at that particular time. By doing so, the surveillance arm of the enforcement organization need only check to see whether or not fishing vessels are in an area during a closed period instead of having to monitor exactly what it is they are doing. Another approach would be to require a check-in, check-out procedure in which all vessels that are to participate in a particular fishery would be required to first check in at a predesignated port so that enforcement agents could ascertain that prohibited types of gear were not aboard and determine the amount of and seal prior catches or catch products before the new fishery is pursued. At the conclusion of a vessel's operation in the fishery, it would be required to check out at a predesignated port, at which time its total catch could be estimated from the volume of fishery products aboard and sampled, if necessary, to determine species composition or the presence of prohibited species.

Perhaps the most straightforward (but costly) method of achieving thorough enforcement would be through the use of observers which would be stationed aboard fishing vessels to monitor directly their activities and catches. Rather than sending observers, at some expense, aboard all fishing vessels the manager may choose to randomly place observers on some small portion of the total fleet, but not so small a proportion so that the fleet could afford to "bend" the operation of a very few vessels to show the observers what they wanted to see while the majority operated without constraint. Of course, all of these measures could be variously combined to fit the practicalities of geography, finance, and fishing practice. The cost of observers, however, might be shared between the enforcement and research arms of the management agency by taking advantage of their presence in the fishing fleet to collect biological data that might otherwise only be available from expensive research vessel operations.

6. ORDERLY TRANSITION

There is little doubt that the world is about to move - either by treaty or widespread unilateral action - from a fisheries regime which favoured exploitation and intense competition to one in which access to and utilization of living marine resources will be rigorously controlled. In the long run, this might result only in a change in who takes the fish rather than how many are taken. Also, in the long run, a unique opportunity to enhance conservation and apply real fisheries management will be available.

The big question is how can the world, through the collective actions of states, move quickly to grasp this opportunity and how can the potential adverse effects of this change be mitigated?

Preventing a serious decline in global fish production translates, at the outset, into protecting the interests of distant-water fishermen, not necessarily in perpetuity, but at least over the period it will take for coastal fishermen to increase their capacity to that of the distant water fleets they will replace. There are a number of avenues for this, aside from treaty provisions which guarantee a long-term and orderly

phase-out of foreign fishing from the economic zone: bilateral arrangements between allies or trading partners; government-to-government or industry-to-government joint ventures; paid access, to name only a few.

Perhaps the most important element in any of these is some arrurance that fishing arrangements with distant-water fishermen or nations are made in a manner that protects the coastal state's options for future domestic fishery development. A coastal state with little fishery expertise of its own would be at a decided disadvantage in negotiating continued access by distant-water fishermen - on the one hand it could be misled by overly optimistic forecasts of sustainable yield and, anxious to obtain some income from its new resources, might agree to foreign removals that could sooner or later lead to depletion. In this case, both the profit potential and the opportunity to develop its own fisheries would be lost, at least for some time. On the other hand, a too conservative view would lessen the income that could safely be obtained on a sustained basis.

Alleviation of these two potential problems rests to a great extent on the confidence of the coastal state(s) in rightly assessing the allowable catch and optimum methods for taking it. That confidence, in turn, is a function of the amount and quality of fishery and resource information on hand and the ability to interpret it. In other words, the necessary ingredients are data and expertise.

Although there will never be enough of either to satisfy the manager, with sufficient expertise a reasonable amount of fishery management can be performed with something less than a complete data base. Furthermore, fishery data that can be used to modify - in almost real time - an initial pre-emptive management programme can be generated quite rapidly from an on-going fishery.

Accordingly, and without downplaying the value of good statistical and biological data, the first and most important requirement for coming to grips with "day-one" management is professional expertise. Therefore, in seeing that reasonable management is quickly attained with the least possible disruption of fish production, an initial consideration must be that of having or making available to the managing entity some degree of fisheries expertise.

Presumably, a management entity would want to eventually develop its own permanent cadre of experts and this should be a defined objective of its management programme. Income from foreign fishermen, taxes on domestic fishermen, technology exchange provisions in joint ventures all could provide the financial wherewithall to train or hire professional talent.

The immediate problem then is "day-one" expertise and this is really the key to an orderly transition to the new regime.

In some cases, the pooling of national jurisdiction into a regional organization might also allow for a pooling of talent. It is not inconceivable that the merging of limited national talent may create a "critical mass" of expertise sufficient to cope with initial management problems until a more complete professional staff can be trained or hired, at which time the fine-tuning can commence.

In other cases, heavy foreign investment in a joint fishery venture may be a sufficient guarantee to the coastal state that management assistance from that foreign government would be reliable.

Yet another possibility, and one that has been mentioned in UNCLOS, is that of an international register of qualified experts, from developed countries willing to underwrite such assistance, from which developing states (regions) could select consultants until suitable permanent arrangements could be made. The UN (FAO) might also solicit and arrange for cooperation with national Academies of Science or other professional societies in designing initial management programmes for developing countries.

Finally, FAO might provide direct management assistance to regional fishery organizations if suitable financial support could be arranged. Perhaps such support could be based on matching funds from FAO and the regional organization, with some or all of the latter's share coming from revenue generated by foreign fishing in the economic zone.

It does not seem unlikely that each of the above possibilities would have a place in one region or another, or that some combination of the above would be apropos to the situation in certain regions. What will be necessary is that the developing coastal states realize the long-term benefits to them of implementing a rational management programme and that an investment of some of their first fishery revenues into a management system will guarantee dividends from then on.

A NOTE ON THE STATE OF FISHERY RESEARCH IN THE NORTH-EAST ATLANTIC

by

Gunnar Saetersdal
Institute of Marine Research
Bergen, Norway

CONTENTS

		Page
1.	INTRODUCTION	78
2.	RESOURCES AND COST OF RESEARCH IN SELECTED FISHING COUNTRIES	78
3.	MECHANISM FOR COORDINATION AND COOPERATION	80
4.	THE ROLE OF FISHERY SCIENCE IN THE DEVELOPMENT AND MANAGEMENT OF THE NORTH-EAST ATLANTIC FISHERIES, A BRIEF HISTORICAL REVIEW	80
5.	PRESENT STATE OF MANAGEMENT AND RELATED RESEARCH	82

1. INTRODUCTION

This note is prepared as background information for discussions of Agenda item 2.: "Evaluation of the impact of expected changes in the regime of the sea on research and management aspect of fisheries." It is relevant to sub-items 2.1: Assessment of the present state of fishery science and 2.2 of the needs and measures to respond to them, but it will also contain elements of interest for item 2.3: policy implications for the conduct of fishery research.

The note is developed along two concepts of "the state of fishery research"; an inventory of the research resources used, and the "state of the art". The subject is very wide and comprehensive and certainly worthy of a more detailed and elaborate analysis than has been possible in this brief note, but it may perhaps serve as a reference point and to some extent as a yardstick for evaluation and planning of fishery research both in developed and developing areas.

2. RESOURCES AND COST OF RESEARCH IN SELECTED FISHING COUNTRIES

Through the kind and prompt cooperation of colleagues some simple and basic information on scientific staff, research vessels and budgets in selected countries was collected and is shown in Table 1 which also lists the fish (and shellfish) landings and their first-hand value.

There are some reservations to be noted concerning the comparability and relevance of the data in Table 1. Only institutions wholly and directly engaged in fishery research are represented, and most of these exclude fish processing technology in their work programmes and limit their activity to research on the national resource base of the fisheries and to the environment as it relates to fish resources. It is thought that the breakdown of the number of scientists into categories provides some further guidance to the objectives of the various institutions, although some differences of interpretation of the key words must be allowed for. The best measure of number of scientists directly engaged in research on marine fish resources is thus probably the sums of the categories: stock evaluation, environment and fishing gear and operations. Most, if not all of the figures of annual total budgets do not include capital costs of the research vessels, but operating costs are included in the respective column. Inclusion of the capital costs would not alter the total budgets greatly. The first-hand values of the landings are, at least for some countries, a poor measure of the economic significance of the fisheries, but they represent the only data readily available. The 9 countries included in the survey account for 75-80% of the total landings from this area (10-11 mill. tons) and the data would thus seem representative.

The following simple conclusions may be drawn: the research conducted on the natural resource base of these fisheries representing close to 8 million tons annual landings with a first-hand value of about 2 250 million US $ equivalent involve:

About 290 graduate scientists
25 research vessels (ranging from 70 to 270 ft.)

About 36 million US $ equivalent annual budget expenditures

Simple arithmetics show that the research costs represent 1.6 per cent of the first-hand value of the landings. This ratio varies considerably between the countries from 0.5 to

Table 1

Research on marine fishery resources and their environment. Scientific staff, research vessels and total research costs in selected fishing countries in the north-east Atlantic and total landings and their first hand value.

Country	Number of scientists					Research vessels (ft.)				Budget mill. US $ equiv. 1974-1974/75		Fish landings -73 or -74	
	Total	Stock evaluation	Environmental	Fishing gear and operation	Other	70-100	100-150	150-190	>200	Incl. R.V.	Excl. R.V.	1000 tons	First hand value mill. US $ equiv.
Netherlands	20	8	5	3	4		1		1	(3.3)	2.3	280	155
Denmark	25	14	6		5				1	1.4		1.800	265
Iceland	21	8	3	1	9	1	2	1		1.9		900	230
France	102	14	6	5	77		1	1	1	5.8		690	627
Fed.Rep. of Germany	60	23	8	12	17		1		2	(5.5)	3.3	456	166
Sweden	29	8	17		4	1			1	1.3		196	60
Scotland	68	(21)	(14)	(14)	(19)	1	1		2	4.3		520	136
England Wales	87	44	20	1	22		1	1	1	7.2		490	194
Norway	45	21	11		13	1		1	1	5.3	3.0	2.360	420
Sum	457	161	90	36	170	4	7	4	10	36.0		7.746	2.253
	287					25							

( ) - assessed

3.7. It is thought, however, that these budget estimates include, at least for some countries, the cost of activities not directly related to fish resources research and they may thus be too high. The figure of 290 scientists is probably a fair estimate of the academic man power engaged in this type of research. Measured against the first-hand value of the landings it represents 8 million $ per scientist.

3. MECHANISM FOR COORDINATION AND COOPERATION

The well known and long traditional (75 years) International Council for the Exploration of the Sea (ICES) is the most important tool for these functions. The Council's field of activity is not limited to fisheries research, but also covers more basic physical, chemical and biological oceanography. Annual statutory meetings ensure a good general contact between marine scientists in the area. Research methods and techniques are standardized and calibrated and research programmes are coordinated often with jointly organized field work. Symposia and publication series are other important means of promoting ocean science. The Council functions as a scientific advisory body to the North East Atlantic Fisheries Commission and to the Baltic Fisheries Commission. These functions are carried out through the organization of series of assessment working groups dealing with fish stocks or groups of stocks. Such working groups are open to participation from all member nations, but the final advice is submitted by the Liaison Committee, an elected group of scientists responsible to the Council.

The staff and budget of the Council is as shown in Table 2 of very modest size and do not reflect its considerable functions and responsibilities. This is because the member countries bear the costs of their participation in meetings and working groups, and these costs would generally be included in the research costs listed in Table 1.

In addition to the international contacts sponsored by the ICES there is a certain amount of bi-lateral coordination and cooperation in marine science, but in the fisheries field this is not of great scope or significance.

4. THE ROLE OF FISHERY SCIENCE IN THE DEVELOPMENT AND MANAGEMENT OF THE NORTH-EAST ATLANTIC FISHERIES, A BRIEF HISTORICAL REVIEW

The role and significance of research relevant to our use of the natural fish resources as such can somewhat schematically be classified and described as follows:

1. Exploratory research on virgin areas or stocks. This includes quantitative and qualitative descriptions, preliminary conclusions regarding available production, and technological advice (fishing areas, seasons, vessels, gear, products).

2. Extensive resource investigations on identified stocks to guide development, prevent over-investment or too early and restrictive management and provide technological advice.

3. Stock assessment monitoring to provide flow of advice mainly for basic management.

4. Advanced management studies on the resource/economy/social problems complex (including interaction between resource units) to advise on optimum usage.

There is a considerable overlapping between these categories but they would tend to represent sequential stages in the historical development of unit fisheries.

In the North-east Atlantic many major fisheries date back several centuries, whereas the first systematic studies of fish resources were initiated during the last half of the 19th

Table 2

International Council for the Exploration of the Sea

Staff and Annual Budget

Staff		Budget (1974/75)	
General Secretary	1	Salaries	$ 222 000
Other professional posts	3	Publications	$ 68 000
Technical Administrative Clerical Staff	14	Meetings, travel	$ 22 000
		Other	$ 89 000
Total	18		$ 401 000

century the incentive being in general the fluctuations in the availability of the resources. A great wealth of descriptive information on the life history of the most important fish stocks was brought forth during the first mainly exploratory period of fishery research in this area which takes us from the end of the 19th century nearly up to the second world war. Already at the beginning of this century the important discovery was made that fish stocks may fluctuate greatly in abundance from natural causes. This discovery explained the often greatly fluctuating yields from sea fisheries which had been a major problem for many countries. Although this generated a general interest in populations as such, the effects of exploitation on the fish stocks and resultant management problems did not attract significant interest until well into the 1930's (except for whale stocks). This first period was thus dominated by research of the first two categories listed above exploratory research and more extensive resource investigations.

The second period from about the second world war up till the present time is characterized first of all by the many problems connected with the management of rapidly developing or fully developed fisheries. Attention was first concentrated on reducing the waste brought about by the too low age at first capture in fisheries on demersal stocks, and most management problems in the 1950's referred to trawl mesh increases. Pelagic stocks were thought to be for practical purposes inexhaustable, a view which was rapidly invalidated by modern fishing technology in the 1960's. It is now evident that pelagic stocks such as herrings because of their concentration in schools and areas, are highly vulnerable to modern fishing and may be reduced to much lower relative abundance levels than other types of fish. As to research in this period an adjustment was made to the new problems by change of emphasis and objectives and a generally greatly increased effort on stock evaluation. Many of the case histories can be seen as a race between fishery and research development, a race which was not always won by the scientists, quite apart from the additional difficulties of applying the advice. Very considerable advances have been made over the last 10 - 15 years in the acquisition of knowledge on the major fish stocks, advances which naturally have been more significantly related to management problems than the research results of any previous period. Still, as I will try to demonstrate in the following section, there seems to be little ground for complacency, we are for most stocks and stock complexes still far from a full understanding of the dynamic processes in the populations and to what extent and how we can influence them by management.

Referring back to the schematic representation of resources research, the emphasis in this second period has been on classes 2 and 3 extensive resource investigations and stock assessment monitoring.

Exploratory research (class 1) did of course also continue as on the herring in the Norwegian Sea, the Barent Sea capelin and recently on the blue whiting in the Norwegian Sea and to the west of the British Isles. The 4th category of research objectives: advanced management studies have so far hardly been attacked. The main and most urgent task till now has been to provide the basic advice necessary to prevent "overfishing" understood as F's significantly exceeding the MSY point for the particular fishing pattern used. But although the information basis for this simple objective has now been available for some time for most stocks, the management body has in general not succeeded in acting on this advice in a satisfactory manner.

5. PRESENT STATE OF MANAGEMENT AND RELATED RESEARCH

The general remarks which end the section above may serve as an introduction to this analysis which although presented in some detail must still be considered only as cursory and far from comprehensive.

Table 3 lists the main stocks of the area, their state of exploitation and state of management. Reasonably effective trawl mesh regulations which already exist have been disregarded in this table, as well as a number of seasonal closures and other measures of minor importance.

Table 3

Selected major stocks or groups of stocks in the Northeast Atlantic and their state of exploitation and management

Stock (group)	Approx. potential production 1 000 tons	State of exploitation	Management measures
Atlanto-scandian herring	1 000	Collapsed	Quota restrictions after collapse
North Sea herring	800	Greatly depleted Y/R and probably reduced R	Non-effective quota restrictions
Minch herring	200	Reduced Y/R and possibly reduced R	Quota restrictions, effectiveness doubtful
Celtic Sea herring	30	Reduced Y/R and possibly reduced R	Quota restrictions, effectiveness doubtful
North Sea mackerel	400	Possibly reduced R	Quota restrictions, minimum landing size
Saithe stocks	600	About to be fully exploited	None
North Sea cod, haddock, whiting	500	Reduced Y/R mainly because of by-catch of juveniles in "industrial fisheries"	Quota restrictions, largely preventive
North Sea sole	15	Considerably reduced Y/R wasteful by-catch of juveniles	Quota restrictions, effectiveness doubtful
North Sea plaice	110	Wasteful by-catch of juveniles	Quota restrictions, largely preventive
Arctic cod and haddock	1 200	Greatly reduced Y/R and possibly reduced R	Quota restrictions, only partial effective
Barent Sea capelin	1 200	Approaching full utilization	Various (national), largely preventive
Faroe cod and haddock	50	Full utilization	Quota restrictions, probably adequate

The precarious state of the pelagic stocks particularly herrings is clearly evident from this table. As regards the Atlanto-scandian herring views on the causes of the collapse differ, ranging from a puristic environment-conditioned natural-based cause to a full fishery-induced effect. An interrelated cause complex may be the most probable answer. The speed with which the collapse occurred is, however, fishery induced. There is, thus, no doubt that the very rapid and drastic decline of the adult stock size from about 7 million tons in 1964 to the order of about 50 thousand tons in 1970/71 was mainly the effect of heavy fishing pressure. Three reasonably abundant year classes were virtually fished out in this period before they could recruit to the mature stock. This is a clear example of research losing the race to technological development. For the other major stock of herring in this area, the North Sea herring, adequate information on which simple management could have been based, was made available in time and the responsibility for the management failure must largely be sought in short-comings within the international community at the administrative level.

Given the rather discouraging picture represented by Table 3 as a whole, one is prompted to try to examine to what extent the well known limitation of the present types of scientific advice with regard to reliability, accuracy and timeliness may have reduced its "action value", and also and perhaps more importantly whether the currently used TAC-assessments generally based on the simple MSY concept represent an adequate, generally acceptable and scientifically sound objective for management.

The short-comings of the present methods have often been discussed and one is sometimes left with the impression that these are mainly functions of the promptness, reliability and detail with which fishery statistics and biological sampling data are submitted. There seems, however, to be rather fundamental weaknesses inherent in the commonly used VPA-analysis, one being that it is basically retrospective. In stocks with flunctuating recruitment, early estimates of recruitment are essential, and too little effort has been spent on developing and improving such measures. Another limitation of traditional assessment methods is that relatively minor changes in biological parameters such as growth rate and maturity age may change the estimates significantly, and although density-dependent growth has been observed in many stocks, the study of such phenomena has received little attention. Also this type of analysis is unsuitable in species with a brief life span, and a high rate of natural mortality (sprat, capelin). Some kinds of direct abundance surveys may be the only alternative here, since effort measures are often unavailable or biased in such fisheries. A similar restricted usefulness of traditional assessments arises in stocks with medium life span, when heavy fishing pressure results in a fishery on few year-classes only as in the North Sea herring at present.

The question of the relevance and usefulness of the MSY concept is of a more fundamental nature. As practised at present in the North-east Atlantic the concept is merely used to give a meaning to the F which under certain assumption of recruitment would give maximum yield (by weight) assuming again an unchanged fishing pattern. Such an F (F max) can of course be applied in any stock state, even to greatly depleted stocks where it is meaningless as a regulation measur and this has been a cause of confusion to fishery administrators. The fact that the concept implies maintenance of an established fishing pattern also causes confusion and seems to seriously limit its use as a general management objective. That its present usage does not include stock-recruitment relationships represents a further limitation, the causes of which are obviously related to the lack, or apparent lack of basic information. These short-comings of the MSY concept may in no little measure have contributed to the management failures in the area and there seem to be sufficient grounds for discontinuing its general use or at least to amend it. The concept has the advantage of being simple and easily comprehensible, but also the related considerable risk of presenting basically complex relationships oversimplified.

There is then a need for a new concept or perhaps more than one for use under different conditions of fisheries and stocks. The concept(s) should meet a number of requirements including the following partly interrelated points:

1) that the exploitation rate on a long-term basis is reasonably close to that corresponding to the MSY/R.

2) that exploitation patterns are as far as possible optimized.

3) that the spawning stock is optimized or maintained within reasonable limits on a stock-recruitment basis.

4) that management may relate to unit stocks or stock complexes as established by fisheries - or ecological relationships.

5) that stock densities are maintained at high enough levels to ensure harvesting without excessive costs.

6) that for stocks with greatly fluctuating year-class strengths the permissible annual catches are maintained with a minimum of fluctuation which implies keeping standing stock size at a fairly high level.

The points 1 - 4 aim at an optimum resource usage while points 5 and 6 represent sensible general management principles. These requirements are well known and most of them have been applied in various combinations in definitions of management objectives. They should be considered as sound general principles to be incorporated in any comprehensive political set(s) of objective of fishery management. Clear political objectives are often lacking even on a national basis. They may consist merely of such requirements or principles as those listed above, but often it will be necessary to take account of special requirements of economic and social nature, e.g., needs of fisheries or coastal communities, present or future nutritional needs, profits, product usage, just to mention a few. The acceptance of a political objective may need a limited modification of some of the basic management principles.

Political objectives of fishery management are often difficult to define in general terms. But for some types of resources and development stages it may still be possible to define principles of resource utilization of a more political nature than those listed above, and this could be important as a guide for fishery development in the third world and for the management of the ocean protein reserves such as the krill and the meso-pelagic fish resources such as the lantern fish, and perhaps also for common-property resources generally.

The list of requirements above could perhaps serve as a basis for discussing a general resource-base concept of long-term optimum resource utilization. It is intended to initiate such discussions in the ICES area where there is a general feeling that more comprehensive and advanced management studies should now be attempted.

EFFECTS OF UNCLOS ON RESEARCH AND MANAGEMENT ASPECTS OF FISHERIES

ASSESSMENT OF LONG-TERM AND SHORT-TERM NEEDS, AND OF MEASURES TO RESPOND TO THEM (COMMON PROPERTY RESOURCES)

Discussion Notes

by

S.J. Holt
Fishery Resources and Environment Division
Department of Fisheries
FAO, Rome, Italy

In so far as it is concerned with living marine resources, UNCLOS had paid attention mainly to one general question: the allocation of rights over, and benefits from these resources, among nation states. In doing so it has largely ignored, or taken for granted the existence of solutions to, other questions, two of which are:

(a) How are benefits to be allocated in time as well as in space?

(b) How should the interactions between different uses of "ocean space" and, specifically, between the uses of living resources and of other resources and properties of the ocean be regulated, and potential conflicts resolved?

However, these questions are real, and serious consideration of them is overdue. If fishery research programmes are to be re-oriented to meet changing situations, these other quetions must equally be considered along with those occupying, at present, the attention of UNCLOS.

The strategy of each nation, in UNCLOS, is to gain as much benefit as it can for itself, on the assumption that other nations will do likewise, and to its detriment. The tactic of all has been to rationalize a particular argument in terms of general "principles", involving mainly the formation of alliances through grouping of categories "coastal", "land-locked", "developing", "disadvantaged", "Latin American", etc. It has not been recognized, in recent discussions, that the end result of each state seeking to secure advantage could be the disadvantage of all or most of them. It is possible that there will be a belated recognition of this possibility, resulting in cooperative actions, with important consequences for the evolution of marine research. The situation is strikingly parallel with the development of overfishing of an unregulated common resource.

The 1958 UN Conference on the Law of the Sea was overtly concerned mainly with allocations in time - hence the efforts, during it, to agree on a definition of "conservation". In reality this was as much to assure continuation of "freedom of fishing on the high seas" to the relative benefit of the main fishing nations in the short and medium terms, as to secure benefits for future generations. UNCLOS has taken over the 1958 definition uncritically. However, some scientists have been re-evaluating the concepts of conservation of management; with respect to fishery resources this is perhaps best exemplified in the Report of the Airlie Workshops (in press). At the same time some lawyers - especially those concerned with aspects of "environmental protection" - have begun to develop new legal concepts; the most advanced review I know of these is by Christopher Stone (1974). The emerging scientific and legal concepts call for new institutions - as Stone points out "no entity can be said to have a legal right unless and until some public authoritative body is prepared to give some amount of review to actions that may be inconsistent with that right". New entities require new kinds of scientific advice.

Man's interests in various forms of marine life fall into three categories:

(a) He regards them as resources, which may have consumptive or non-consumptive quantifiable "values".

(b) He is concerned with the rôles they play in marine ecosystems.

(c) He places cultural, including scientific, non-quantifiable "values" on them.

Until recently any particular line of marine research could be seen usually as falling into one of three parallel categories. The distinctions between these categories are becoming blurred. One reason for this is to be found in shifting and spreading interests. The shifting results in part from more extensive and less selective uses of elements of marine ecosystems (so, for example, we may need to study the dynamics of animals which form the diets of a number of resource "stocks"); in part from changes in human activities outside the marine system (leading, for example, to assigning a "cultural" as well as a "resource" value

to some of the mammals). The spreading of interests results from the marine ecosystem becoming a focus of attention of increasing numbers of peoples of diverse cultures, often looking further and further from their own shores; and also from the energies of a variety of interested groups of persons, within nations.

Marine resources research has so far been largely concerned with providing a factual and conceptual basis for resolving conflict with respect to a particular kind of interest; specifically to regulate competition between groups of exploiters so that it does not jeopardize their medium-term interests. This applies also to such conflicts as between different consumptive uses of the same animal (e.g. sport and commercial fishing) and between consumptive and non-consumptive uses.

While these problems remain, to them are added the conflicts arising from the shifts in kinds of interest - for example whether a fish stock is regarded mainly as a "resource" itself, or as the food of another "resource", or both.

The area of potential conflict is expanding even further - to the increasingly competitive use of ocean space. Not only may one use directly, and immediately, interfere with another use (and hence call for regulation of uses), but the different uses usually have very different time characteristics - both in scale and reversibility. The diversification of conflict situations and, inevitably, of the international arrangements for resolving, or confining them, call for a broadening of research perspectives.

Simultaneously a new view of the kinds and consequences of natural change is gaining ground. Much of fisheries research literature deals, on the one hand, with an assumed constancy (steady states, sustainable yields), and on the other with "fluctuations". Is there now more consciousness of medium and long-term natural trends; and, if so, what are the consequences for the definition of management objectives?

The problem of allocation of benefits in time has been considered, in the past, almost entirely in terms of physical quantities (e.g. sustainable yields). This view has been disturbed by, on the one hand, the consideration of non-physical quantities (e.g. discussion of discount rates) and, on the other hand, by the realization that future human generations may place qualitatively different values on a "resource" than we do; this leads to the introduction among management criteria of "leaving a diversity of options for future use". This criterion is strengthened by the emergence of new nations, or other social groups which, while not using a common property resource, now wish both to reserve the right to do so, in some way, in the future, as well as to ensure the resource is kept in a state which makes it feasible for them to exercise that right.

Intensification of a particular use of a resource leads to greater demands on scientific advice - e.g. more required precision in estimates of potential yields or of effects of catch level. Changes in attitude to management add to these demands with respect for example to hitherto unexploited or lightly exploited resources, so that there are demands for estimates of the consequences of exploiting resources that have neither been studied nor changed by human agency.

Thirdly, the increasing problems of multiple use of resources, of ocean space and of interactions call for analysis and prediction of ecosystems rather than of populations. At the same time, after several decades of optimism, we are increasingly aware of our inability still to predict the responses of populations to exploitation; hence the reference in the Airlie Report to the need to allow margins of error; at least in some cases these margins must be quite wide. We are even further from an ability to predict ecosystem responses. This has led to some suggestions for empirical experimental approaches to resource management but scientists have still given little serious attention to this; UNCLOS decisions might make such suggestions more realistic and thus call for appropriate "experimental designs".

In addition, just as biologists were slow to realize that in order to predict population response it was more important to have rough estimates of all relevant parameters than accurate estimates of only some of them; so it may be desirable to develop methods of appraising roughly the interactions between all or nearly all the major components of ecosystems rather than to study the details of only some of them.

It might be useful for the ACMRR to arrange for a study of the implications of the above trends for research on selected ecosystems; I suggest two:

(a) Southern Ocean (whales, seals, krill, fish, birds) as an example of one which has so far been exploited extremely selectively.

(b) North Pacific - Bering Sea (fur seals, sea lions, pollack, etc.)

or

(c) North West Atlantic (cod, capelin, whales, harp-seals, etc.) as one which is already subject to a changing variety of exploitations.

In addition, a case study of an area of multiple space use and the institutional arrangements for scientific advice might be useful; possible areas are North Sea - for which a review has recently been published (Sibthorp 1975) - or the Mediterranean.

REFERENCES

Sibthorp, M.M. (Ed.), 1975 The North Sea: challenge and opportunity. London, Europa Publications for the David Davis Memorial Institute of International Studies, 324 p.

Stone, C.D., 1974 Should trees have standing? Towards legal rights for natural objects. Los Altos, California, W. Kaufmann, Inc., 102 p.

Workshops on the Conservation of Wild Living Resources, 7-14 February and 4-7 April, 1975. 1975 Report of Airlie, Virginia, (in press). Extracts issued as FAO/ACMRR/MM/IV/3: 17 p. April 1975

THE TOTAL BIOMASS APPROACH TO FISHERIES MANAGEMENT

by

R.L. Edwards
Northeast Fisheries Center
National Marine Fisheries Service
Woods Hole, Massachusetts, U.S.A.

In October 1973 at a special meeting of the International Commission for the Northwest Atlantic Fisheries (ICNAF) held in Ottawa, Canada, the ICNAF nations agreed to an overall quota for finfish, including squid, but excluding certain other species such as the menhaden, tunas, swordfish, and other high seas pelagics. This overall quota, presently termed the "second tier quota" was set at 924,000 metric tons for 1974, and at the subsequent Annual ICNAF Meeting at 825,000 metric tons for 1975. At the present time (August 1975) the overall quota for 1976 is in dispute, but at the 1975 Annual Meeting it was set at 650,000 metric tons, excluding squid.

The first direct approach to the need for management of the total fish ecosystem was made at the Annual ICNAF Meeting in June 1972, when a two-part document entitled "A Preliminary Evaluation of the Effects of Fishing on the Total Fish Biomass, and First Approximations of Maximum Sustainable Yield for Finfishes in ICNAF Division 5Z and Subarea 6" (ICNAF Research Document 72/119) was presented. Part I (Grosslein, op. cit.) concerned the changes in relative biomass of groundfish and Part II (Brown, B.E. and Brennan, J. op. cit.) concerned the relationship of total fishing effort to the yield.

The particular attention given to the fish sector of the ecosystem at the laboratory in Woods Hole has been as much a matter of tradition as necessity. Although for many years "haddock was king", it was recognized by fishery biologists even before World War II that the species sought in the region from Cape Hatteras to Nova Scotia were many and that the various fisheries significantly interacted with one another. As a consequence, systematic groundfish surveys began in the 1950's and a considerable amount of effort was put into understanding the nature of variability of trawl catches (Taylor, 1953). In 1963, the groundfish surveys were rigorously systematized (Grosslein, 1969) and are continually providing increasingly valuable insights into the fish community and its interaction with other components of the overall ecosystem. Also in the 1950's, because of concern that by-catch in other fisheries was inadvertently reducing the yellowtail flounder population, an intensive study of Southern New England's industrial fishery was undertaken (e.g. Edwards, 1958). These data, among other things, demonstrated the degree to which it was impossible in a trawl fishery to even remotely achieve pure catches of any particular species on a regular basis. Other papers that have dealt with the fish ecosystem and the mix of species generally include Edwards, 1968, and Grosslein and Bowman, 1973.

The total ecosystem quota approach was developed for many reasons, two of which are most important; 1) the by-catch problem and 2) the desire to maintain the ecoystem in its most productive and useful state. The first of these lends itself reasonably well to documentation and analysis, the second is more intuitive and exceedingly difficult to demonstrate scientifically, although the principles seem clear enough.

The by-catch problem was most recently discussed by Edwards and Hennemuth (1975) in a general article dealing with the semantic confusion concerning maximum sustainable yield and related biological concepts. Put very simply, few if any fisheries, and certainly no trawl fisheries, are characterized by catches only of the species sought. The mixed species situation is pronounced in many areas of the continental shelf. It can become critical wherever fishes are managed by species quotas and most, if not all, of the available species are sought. The problem is further exacerbated in a trawl fishery if there are large differences in the size of meshes used by the different fisheries. A small mesh fishery may be mitigating the benefits of a large mesh fishery for a different species, by taking small fish as by-catch.

Fisheries cannot be usefully classified as "haddock" or "herring" fisheries if the by-catch is ignored. The by-catch is ignored if it isn't documented, whether it be discarded or consigned to the fish meal plant. In many cases in ICNAF Subarea 5 and Statistical Area 6 the by-catch of some species has equalled or exceeded the species quota. For those countries or fisheries having their quotas taken inadvertently by another fishery is quite an unsatisfactory situation. For the biologist attempting to make sense out of his population data, the unrecording by-catch puts him in an untenable situation, usually that of underestimating the fishing mortality imposed, overestimating the natural mortality and generally

being unable to adequately explain the observed changes in populations. These changes, then, are all too often rationalized by invoking still more inadequately documented changes in the physical environment, a highly questionable but too easy procedure that entirely ignores all the potential and more likely biological interactions that are taking place.

There are innumerable possible analytic solutions to the problem of dealing with the allocation of catches when the by-catch is a problem but all of them require an inordinate amount of data and analysis. It is far simpler, more understandable, and quite probably more equitable to put a limit on the overall catch and mandate the cessation of fishing when the limit is reached, regardless of the species mix. This approach also has the practical virtue of encouraging the cleanest possible individual fisheries. Individual species groups, or species, or stock quotas also need to be maintained to prevent overexploitation of particular groups.

For greater detail and analysis of the by-catch problem the paper by Brown, Brennan, Heyerdahl, and Hennemuth (ICNAF Research Document 73/99) is an excellent reference.

The second general rationale for the ecosystem quota, that it offers the best approach to date for maintaining the ecosystem in its most productive and useful state to man, is far less easy to demonstrate although intuitively obvious.

From man's point of view and from the standpoint of his technological capabilities, fishes in general and certain large invertebrates, e.g. lobsters, squid, and clams, are the most useful form of protein provided by continental shelf ecosystems. There is neither the desire nor the capability, for example, to harvest amphipodes, copepods or euphausiids. Certainly the standing crop of all such creatures exceeds that of the fishes. The decision to seriously harvest these components of the ecosystem should only follow and not precede the deliberate decision to substantially reduce or eliminate fishes as a protein resource, since they, the invertebrates, are directly or indirectly the food supply of fishes.

It is generally believed by ecologists that ecosystems "in balance" are more productive, or efficient, than those which have been significantly disrupted or distorted by whatever mechanism. Lee R. Dice (1952) states it this way - "It may be assumed that the most efficient utilization of the resources of any given habitat is obtained when the community occupying the habitat is well organized and regulated so that no very violent fluctuations in the populations of the member species are produced, even by considerable variations in the weather or in the physical conditions of the habitat."

The terms "ecosystem" and "community" are used interchangeably in this paper. On land, the term "community" is particularly useful because it can be related to so many relatively fixed conditions, e.g. the beechmaple forest of Southern New England. Except for benthic communities on or in continental shelf sediments, the boundaries of most marine communities are highly variable both in time and space and hence "ecosystem" seems the better term. Further, it should be noted that the term "total biomass" is not to be confused with production. The productivity of any ecosystem is determined by the particular constituents of that community and the rate at which they accrue, fix, or otherwise deal with the available energy. The term "biomass" has been used in this instance because the management measures developed came directly from analyses of the changes in biomass as they related to fishing effort.

All ecosystems or communities are in a continual state of change. They tend toward a central theme, not point, of equilibrium, that which is the most efficient in terms of utilization of the available energy. All ecosystems react and adjust, often very rapidly, to changes which continually occur. These changes include such events as birth and death, growth, migrations, changes in the physical environment, and the introduction of new organisms, either de novo or from outside.

Marine "fish" ecosystems do exist over long periods of time in a recognizable state of dynamic equilibrium. Even though the precise species may vary between the North Sea, the

Northwest Atlantic off New England and Nova Scotia, the Northwest Pacific, and even on the continental shelves of South Africa and South America, there is a marked ecological similarity between them that leads a fishery ecologist to feel that he is dealing with familiar "faces" and "forces" as he goes from one to the other.

Marine "fish" ecosystems appear to be as stable as terrestrial ecosystems, but they are very different in dynamic terms. The dynamic principles are the same but the scales of events are different.

Primary production in the ocean is overwhelmingly accomplished by single cell plants, the phytoplankton. Individually, they are seldom discernible to the naked eye. On land, plant life is plainly visible and comes in sizable "pieces", fixed in position, with the consequence that herbivores can be very large, like giraffes, gazelles, and guinea pigs. In the oceans, organisms really can't afford to be both herbivorous and very large. Those that are highly specialized in their anatomy, physical niche, region of occurrence, or a mix. Ocean herbivores generally are tiny. Some obvious exceptions are some mollusca and apparently certain pelagic fishes such as menhaden (although even here it isn't certain that the menhadens' diet is strictly phytoplankton).

The typical ocean primary carnivore is also a small organism, as for example, other species of copepods, arrow worms, or ctenophores.

The typical marine fish is a hypercarnivore which is often so eclectic in its diet that one can only state very generally at what level of the carnivore scale any particular species exists at any particular time or place. In some cases, such as the silver hake Merluccius bilinearis where there appears to be considerable cannabalism at times, the species must often be considered a fifth or higher level carnivore.

Marine fishes are extreme "r" strategists. For a good general discussion of "r" and "K" strategies, see Miller and Botkin, 1974. One would intuitively assume that this must be the case because so many of the geographic stabilizing forces of terrestrial communities are lacking in the oceans and it is necessary for marine organisms to be markedly opportunistic, biotic and physical conditions being as variable as they are. On land, plants tend to provide a kind of stability that can persist for centuries - for example the beechmaple forest of northeastern United States or the tiagas of Siberia. As a consequence, a variety of geograpically stable microclimates are produced and a rhythm of production on the part of all organisms results that often continues for countless generations of land organisms. Highly specialized creatures develop with most herbivores and carnivores being "K" strategists by comparison - quite at the other end of the production spectrum.

In the case of "K" strategists, there are usually easily detected intraspecific and interspecific density dependent controls, as well as density independent controls, on the rate of production of offspring. For example, many birds will lay more eggs or have additional broods when the environment is favourable, food is abundant and competition territories is minimal and vice versa when conditions are unfavourable. The "sieves of survival" come into play, therefore, even before the young are produced. In the case of marine fish the situation is quite the reverse. Very large numbers of eggs are produced with relatively little detectable preliminary adjustment on the part of the adults to the survival potential of the young in consideration of the existing biotic or physical environment at the time of spawning. Under these circumstances, the stochastic sieves of survival for fish eggs and larvae are manifold, exceedingly complex and extremely demanding. It is not surprising that it has been so difficult for fishery biologists to demonstrate stock-recruitment relationships.

Existing at the trophic level (hypercarnivore) that they do and being as eclectic in their diet as they are, the feeding niche of marine fishes is best described in functional terms. Fishes tend to feed in particular parts of this environment and are adapted accordingly as on the bottom or in mid-depths, for motile or non-motile organisms. Competition seems to be less for particular food items but rather for food generally.

Among the larger crustaceans in the Northwest Atlantic are several species of euphausiids, especially Meganichthyphanes norvegicus and Thysanoessa inermis. These species are significant food items in the diets of the larger individuals of many species including haddock, cod, silver hake, red hake, pollock and herring. (cf. Vinogradov, 1972; Wigley and Theroux, 1965). Should one or more of these prey species either greatly increase or decrease in number, the effects would be felt by many members of the community but in all likelihood not be reflected by measurable changes (with our present tools) in the populations of fishes themselves, but by equally hard or harder-to-measure changes elsewhere. For example, it has been suggested many times that one of the principal predators of shrimp Pandalus in the Gulf of Maine is the silver hake. One could expect, if this in fact is so, that a significant reduction in euphausiids in the Gulf of Maine could lead to increased predation on shrimp. One would not expect, however, that events in the population of one fish species would lead directly to a compensatory reaction in any other particular fish species. There is an abundance of options in the ecosystem. It is probably as logical to propose that certain carnivorous invertebrates would gain as much from a significant reduction in a species like the herring as would another fish such as the mackerel.

While other fish are significant food items in the diet of fishes, in some species more so than others, most appear to rely largely on invertebrates. An intense fishery for one or more of the more abundant species would not appear to directly reduce any important prey species for any particular species. Rather there is a pervasive overall effect and the ecosystem must adjust accordingly. This situation is somewhat different, however, in the case of the squid fishery. Squid (two species) are eaten by at least 60 of the species of fish that occur in the southern part of the ICNAF region and are substantial food items in the diets of several (R. Wigley, personal communication). The adjustments to the removal of squid are judged to be more direct in their impact on the fish population generally. However, to date, with the exception of squid, the existing fisheries in this area do not appear to be interfering excessively or directly with the prey species utilized by any one other particular species taken commercially.

There are, however, some suggestive observations of adjustments recently including, for example, a reported increase in the amount of small yellowtail flounder in the cod's diet, presumably as a substitute for herring and squid. Daan (1973) in his excellent studies of the feeding habits of North Sea cod has succeeded in documenting the probable course of adjustments in certain species. Certainly dramatic adjustments have been and are being made as the result of man's fishing activity in the marine ecosystem but they are not all clearly discernible as yet.

All these things taken together, namely the extreme "r" strategy position of marine organisms, the nature of the food chain, the flexibility of diet and many more factors strongly argue against man carelessly distorting the marine fish ecosystem, because these systems are still so poorly understood in their complexity that the effects of any action cannot be described and because such actions promise only to degrade the system's efficiency.

It is a severe enough distortion when fisheries take all species more or less in proportion to their naturally occurring levels of abundance but there are other distortions that inevitably follow fishing that could have serious repercussion in the long-term sense. There is growing evidence that the time of spawning in some species varies significantly with the age of the fish. This strategy would seem to increase the probability that some of the eggs at least would find themselves in optimal circumstances. Exploitation reduces the mean age of fish populations and could, consequently, further decrease the probability of a successful spawning in those species.

Man's present activities are comparable to adding a very large population of so-called apex predators such as sharks and some whales and whale relatives. Such are not now very abundant nor do they ever appear to have been very abundant. One is compelled to ask why? The only obvious answer seems to be that there is no ecological basis for their continued, successful presence in the community at such population levels. This certainly raises the question then of the degree to which man can continue to harvest without seriously upsetting

the ecosystem and reducing its efficiency, at least in his terms. We should proceed with due caution, and for the time being at least not deliberately distort the ecosystem by disproportionately reducing populations or by stepping down in the food chain any more directly than we already have. It seems likely as well that the only sustainable harvest possible that doesn't drastically reduce the productive efficiency of the marine fish ecosystem is one that is substantially less than MSY.

REFERENCES

Daan, N., 1973 A quantitative analysis of the food intake of North Sea cod, Gadus morhua. Neth.J.Sea Res., 6(4):479-517

Dice, L.R., 1952 Natural communities. Ann Arbor, Mich., University of Michigan Press, 553 p.

Edwards, R.L., 1958 Species composition of industrial trawl landings in New England, 1957. Spec.Sci.Rep.USFWS (Fish.), (266):23 p.

_____, 1968 Fishery resources of the North Atlantic area. Univ.Wash.Publ.Fish, 4:52-60

Edwards, R.L. and R.C. Hennemuth, 1975 Maximum yield: assessment and attainment. Oceanus, 18(2):3-9

Grosslein, M.G., 1969 Groundfish survey programs of BCE, Woods Hole. Commer.Fish.Rev., 31(8-9):22-30

Grosslein, M.G. and R. Bowman, 1973 Mixture of species in subareas 5 and 6. ICNAF Redb., (3):163-207

Miller, R.S. and D.B. Botkin, 1974 Endangered species: models and prediction. Am.Sci. 62(2):172-81

Taylor, C.C., 1953 The nature of variability in trawl catches. Fish.Bull.USFWS, 54:145-66

Vinogradov, V.I., 1972 Studies of the food habits of silver and red hake in the Northwest Atlantic area, 1965-67. ICNAF Res.Bull., (9):41-50

Wigley, R.L. and R.B. Theroux, 1965 Seasonal food habits of highlands ground haddock. Trans.Am.Fish.Soc., 94(3):243-51

PRESENT SCIENTIFIC CAPACITIES IN DEVELOPING REGIONS

by

J.-P. Troadec
Fishery Resources and Environment Division
Department of Fisheries
FAO, Rome, Italy

A complete evaluation of the scientific capacities of a country or region involves a high degree of subjective judgement - just how good a particular piece of research is cannot usually be decided objectively until long after the work is published. Further, there are different possible criteria on which the work may be judged - e.g. as pure research, or as the basis for advice to decision makers. For example, in terms of the common (though not necessarily very satisfactory) criteria for judging the standard of pure research - the number of papers published in well-recognized scientific journals - the Instituto del Mar del Peru probably comes well behind most corresponding European institutions, but in terms of the advice offered to the Government, and the use made of that advice, it would score very highly.

However, certain quantities can be objectively measured that must be fairly closely related to research capacity - at least on the average or over the long-term. For example, even though one outstanding man can provide as much or more research results as several run-of-the-mill scientists, the more scientists, and particularly the more scientists in certain important fields, the better the research that is likely to be done. To be effective these scientists must be supported by laboratory facilities, ships, computers, etc., so that the number of ships, and money (and the money spent per scientist) will give some measure of the likely effectiveness of the research efforts.

Finally, the ability and willingness of a country to support fishery research will be determined on the one hand on its overall capacity to carry out research - e.g. total number of trained scientists, total GNP, or GNP per head - and on the other the proportion of the total research that is directed towards fisheries - which may be based on the total value of fish landed, fisheries product as a percentage of GNP, etc.

To enable ACMRR to judge the present research capacities, and the practicability of increasing these capacities in the medium or long-term, some of the quantitative measures discussed above have been set out in tables.

These tables give some information on fishery research in four world areas, i.e., Australia, Eastern Central Atlantic, Northern Europe and South-eastern Pacific. Data for Australia and Northern Europe are taken from Allen (1975) and Saetersdal (1975) respectively. For the other two regions, information has been directly collected from national fishery research institutions. For Northern Europe and South-eastern Pacific the statistics given do not refer to all countries in a given area as it has not been possible to collect the required data for a few of them.

In the tables the following information is provided:

(i) total number of fishery and marine scientists by main field of research (i.e. resource evaluation experts sensu stricto, other fishery biologists and environment specialists). Specialists on fishing gear and fish products development were excluded since (a) experts in technology development are very few in developing countries, (b) most of them - especially expatriates - are more involved in transferring existing technology rather than in developing new techniques. Biologists mainly involved in fishery administration, as well as in teaching have also not been considered in this review. Allocation of expatriate experts presents some difficulties as in certain cases they are paid, at least partly, from national budget (Morocco, Senegal, etc.)

(ii) wherever available, figures on existing research vessels

(iii) wherever available, figures on national expenditure devoted to fishery research. Such data were unavailable for the countries surveyed in South America and North-west Africa. It should be noted here that for some West African countries a part of the fishery research undertaken at national level is financed by foreign sources (the same applies to staff).

Such data on research costs have been complemented by statistics on relative importance of national and regional fisheries (catch in weight and value), wealth (GDP), population size.

Various indices have been calculated from these two sets of data so as to compare the proportion of national resources that each country or each group of countries devotes to fishery research.

Finally, in table 5 some data are given on the total number of scientists and total expenditure for all - not only marine - fields of scientific and technical research.

Table 1

Northern half of Eastern Central Atlantic (Gibraltar - 10°N) - means and resources available in Fisheries Institutes (excluding those devoted to teaching, to fishery administration, to fishing gear and products technology)

		Resource Evaluation	Other Fishery Biology	Total Fishery Science	Marine Environment	Research Vessels	G.D.P. 10^6 $ (1970-73)	Population 10^6 (1973)	National Catches 10^3t (1973)	National Catches 10^6 US $ (1973)
MOROCCO	N	1	0	1	1	10-19m:0	3750	16.3	377.4	34.0
	E	4	1	5	0	20-29m:2				
	Σ	5	1	6	1					
CANARY ISLANDS/ SPANISH SAHARA	Σ = N	4	4	8	9	10-19m:(1) 20-29m:(1)	(1630)	1.6	(367.7) 1/	(165.0)
MAURITANIA	Σ = E	0	2	2	0	10-19m: 1	220	1.7	(10.0)	(3.0) + fees #5.0
SENEGAL	N	1	0	1	0	20-29m:1	1090	4.2	303.8	91.2
	E	5	3	8	1					
	Σ	6	3	9	1					
GAMBIA	N	0	1	1	0		50	.5	5.2	.8
	E	0	1	1	0					
	Σ	0	2	2	0					
GUINEA BISSAÕ	Σ	0	0	0	0		340	.5	1.7	.5
GUINEA REPUBLIC	Σ	0	0	0	0		300	4.2	5.0	(.7)
SIERRA LEONE	Σ = N	2	7	9	1		370	2.6	50.3	7.4
TOTAL	N	8	12	20	11	10-19m:2	7750	31.6	11.20	(310)
	E	9	7	16	1	20-29m:4			TOTAL CATCH AREA: $2.9\ 10^6$t	
	Σ	17	19	36	12					

INDICES	MOROCCO	CANARY ISLANDS	MAURITANIA	SENEGAL	GAMBIA GUINEAS	SIERRA LEONE	REGION
GDP (10^3 $)/Fishery Scientist (National/Total)	3750/625	204/204	-/110	1090/121	Insignificant scientific capabilities	41/41	388/215
National catch (10^3t)/Fishery Scientist	377/ 63	46/ 46	-/ 5	304/ 34		6/ 6	56/ 31
National catch ($10^6$$)/Fishery Scientist	34./5.7	20.6/20.6	-/ 4.0	91.2/10.1		0.8/0.8	15.5/8.6
Regional catch 2/ (10^3t)/Fishery Scientist							145/ 81
Regional catch 2/ ($10^6$$)/Fishery Scientist							(40.1/22.3)
Population (10^6)/Fishery Scientist	16.3/2.7	0.2/0.2	-/ 0.9	4.2/0.5		0.3/0.3	1,6/0.9

NOTES Symbols ( ) = guesses or estimates; N = nationals; E = expatriates; Σ = total number of scientists in the country

1/ Assuming that all Spanish catches reported by Spain as caught in CECAF (actually only those landed in Canary Islands) correspond to Canary Islands activity; probably partially wrong since some boats based in Continental Spain should land in the Canary Islands; similar difficulties in allocating Spanish scientists.

2/ Assuming that coastal countries will progressively have full responsibility over the research and exploitation of all shelf resources

Table 2

SOUTH EASTERN PACIFIC (Columbia, Peru, Chile)
Means and resources available in fisheries institutes (excluding those devoted to teaching, fishery administration, technical studies on fishing gear and products)

	Resources Evaluation	Other Fishery Biology	Total Fishery Science	Marine Environment	G.D.P. 10^6 US $ (1970-73)	Population 10^6 (1973)	National 10^3t (1973)	Catches 10^6 US $
COLUMBIA	1	4	5	6	7 777	23.2	91.2	(24.)
PERU	4	20	24	8 1/	6 178	14.9	2 299.3	85.9
CHILE 2/	8	10	18	18	8 812	9.6	664.4	9.2
TOTAL	13	34	47	32	22 767	47.7	3 054.9	(119.)

INDICES	COLUMBIA	PERU	CHILE	3 COUNTRIES
G.D.P. (10^3 US $)/Fishery Scientist	1 555	257	490	484
Catch (10^3t)/Fishery Scientist	18.2	95.8	36.9	65.0
Catch (10^6 US $)/Fishery Scientist	(4.8)	3.6	0.5	(2.5)
Population (10^6)/Fishery Scientist	4.64	.62	.53	1.01

1/ Probably underestimated
2/ Excluding about 20% devoted to teaching

Table 3

AUSTRALIA: Means and resources for fishery research

No. Scientists 1/	104
Expenditure (10^3 US $) - research	7 580
- management	5 080
- total	12 660
No. Research vessels 10-19 m	4
20-29 m	5
>30 m	1

1/ Excluding CSIRO oceanographers

Table 4

Comparison of scientific capabilities of four world areas

	AUSTRALIA 1/	NORTHERN EUROPE 2/	EAST CENTRAL ATLANTIC 3/	SOUTH-EAST PACIFIC 4/
No. Fish Scientists (including Marine Environment, without technologists)	104	251	48 (of which 17 expatriates)	79 5/
Research vessels 10–19 m	4	?	?	?
20–29 m	5	4	4	?
>30 m	1	21	0	?
Fishery research expenditure (10^3 US $)	12700	36000	?	?
Catch weight (10^3 t)	123.5	7746	1120 6/	3055
Catch value (10^6 US $)	121.	2253	(310)	(120)
GDP (#1970) (10^6 US $)	36600	(814000)	(7750)	22800
Population (10^6 US $)	13.0	191.8	31.6	47.7
INDICES				
Fishery research expenditure/Scientist	122.1	143.4	?	?
Catch weight (10^3 t)/Scientist (10^3 $)	1.2	30.9	36.1/nat.sc. 23.3/tot.sc.	38.7
Catch value (10^6 $)/Scientist	1.2	9.0	10.0/nat.sc. 6.5/tot.sc.	1.5
GDP (10^6 $)/Scientist	352.	324.3	250/nat.sc. 161/tot.sc.	289
Population (10^3)/Scientist	125	764	1019/nat.sc. 658/tot.sc.	604
Fishery research expenditure/catch value(%)	10	1.6	?	?

NOTES

1/ Allen 1975, Pacific Science Congress (Table 3)

2/ Countries included: Netherlands, Denmark, Iceland, France, Fed.Rep. of Germany, Sweden, Scotland, England/Wales, Norway; from G. Saetersdal, ACMRR 8/75/WP.13

3/ All countries and territories (including Canary Islands but excluding Cape Verde Islands) from Gibraltar to lat. 10°N (Table 1)

4/ Colombia, Peru, Chile (Table 2)

5/ Probably underestimates

6/ Total production for the same area (i.e., including catches by non-coastal countries = 2.9 10^3 t)

Table 5

Importance of research (all fields) in national budget of some countries (Source = UN Statistical Yearbook, 1973)

	Eastern Central Atlantic	South Eastern Pacific	Northern Europe
	Senegal	Chile/Peru	1/
Total number of scientists (all fields research/development)	392 (1972)	5760 (1969/70)	224442 (1970)
GDP (10^6 $)/Scientist	2.8	2.6	3.6
		Colombia/Peru	
National expenditure (10^6 $) (all fields research/development)	8.63	9.22	9943
$^o/_{oo}$ of GDP	7.9	0.7	12.2

Note:

1/ Denmark, France, Fed.Rep. of Germany, Netherlands, Norway, UK, Sweden (i.e., about the same list as in Saetersdal's note ACMRR 8/75/WP.13)

REFERENCES

Allen, K.R., 1975 — Fishery Management and research in Australia. Paper presented at the 13th Pacific Science Congress, Vancouver, B.C., 18 - 30 August, 1975

Saetersdal, G. 1975 — A note on the state of fishery research in the North-east Atlantic, ACMRR 8/75/WP.13

PROBLEMS IN MULTI-SPECIES FISHERIES

by

J.A. Gulland
Fishery Resources and Environment Division
Department of Fisheries
FAO, Rome, Italy

CONTENTS

		Page
1.	INTRODUCTION	106
2.	MANY SPECIES CAUGHT IN THE SAME FISHERY	106
3.	INTERACTION BETWEEN SPECIES	107
4.	FISHERIES IN DIFFERENT AREAS	108
5.	GENERAL CONSIDERATIONS	109
6.	MATTERS FOR DISCUSSION	109

1. INTRODUCTION

The traditions of fishery research, and particularly fish population dynamics (e.g., Baranov, Ricker, Beverton and Holt, Schaefer to mention a few) have been built on the analysis of events within a population of a single species of fish with fishing being often the only external factor considered. Historically, also, many major fisheries were based on single species, and some still are (e.g., Peruvian anchoveta). Increasingly, however, fisheries are concerned with several or many species. 3 cases can be described: (a) a number of species are taken at the same time (e.g., in tropical trawl fisheries), (b) different fisheries act on species living in the same area, which interact (e.g., cod and herring in the North Sea), (c) the fishery moves from species to species possibly in different areas so as to maintain its catches in the face of fluctuations in individual stocks, sometimes induced by fishing (e.g., the U.S.S.R. long-range fleets, or, within a more restricted area, the Norwegian purse-seine fishery). In addition, fishery scientists have to an increasing extent to take note of, and advise upon, the impact of other human activities, e.g., waste disposal, on fisheries.

All this means that the single-species approach, as generally applied in the past, cannot deal with all the problems, though in passing it may be noted that the usefulness of single-species models, even in complex situations, should not be ignored. Between the thirties and sixties catches in the North Sea doubled, with great changes in the species balance in the catches, but of these changes something like 70 percent could be accounted for by single-species analyses (principally by changes in fishing effort on each species, and by recruitment failure caused by reduced adult stock), and only 30 percent involved multi-species interactions (e.g., increase in cod and haddock due possibly to less predation by herring and mackerel). Possibly of more practical importance it appeared that the inter-specific interactions did not invalidate the management advise to any significant extent. However, it cannot be assumed that this happy situation will always occur. In the long run any fishery scientist wishing to understand what is happening in the sea must look at more than one species. This applies to the whole range of data supply and research budget - at the one hand the scientist in charge of a large well-financed team trying to build a quantitative understanding of the whole system from sunlight to fish market, and at the other, the man trying to understand a multi-species fishery with research facilities barely adequate to study one species in any detail.

These two extremes suggest that the multi-species problem is not a single problem, and a variety of approaches to the set of problems is needed. These are discussed below with reference to the three groups of multi-species fisheries discussed above.

2. MANY SPECIES CAUGHT IN THE SAME FISHERY

The typical example of this fishery is the trawl fisheries of tropical areas, e.g., the Gulf of Thailand or the East China Sea. A single haul may take a couple of dozen species, and the total number of species involved may run into hundreds. Separate single species analyses of more than a small fraction of the catch is clearly impossible. Even the estimation of the exact species composition of the catch can require major research effort when the fishermen and the fish buyers do not distinguish between closely related species. The practical approach to this situation, taking account of the shortage of data, and the need to make some analysis of the situation, has been to treat the total biomass of fish as though it were a single species, and apply the Schaefer/surplus production type of model, e.g., to plot total catch, or catch per unit effort against total effort. This may be modified to take account of the different values of the various species, e.g., by considering only the combined catch of the higher valued species, excluding the trash fish, or by weighting the main groups (as distinguished by the fishermen, and thus for which it is comparatively easy to get statistics) according to their commercial value.

This procedure is possibly more realistic, as well as more convenient, than attempting a whole series of independent single-species analyses, since the changes in total biomass will, in due course if not immediately, take account of the interactions between species. Of course each single species analyses could be extended to take account of the interaction between species, e.g., changing the growth parameters of a predator according to the abundance of the prey. But this adds a further degree of complexity to a situation which is already too complex, in respect of many tropical fisheries, to be dealt with.

The question is, recognizing that a combined biomass analysis is likely to be the only practicable one for many fisheries, what are the ways in which misleading conclusions could be drawn, especially concerning the state of the stock, and the effects on catches of increases or decreases in the amount of fishing? Can particular circumstances be identified that make misleading results more likely (e.g., because the fishery is somewhat selective on particular species)? If they are likely, what additional studies might be useful? For example in the Gulf of Thailand regular trawl surveys by research vessels provide good information on the changes in species composition, as well as in overall catch rate. This species data cannot, in the absence of detailed statistics of commercial catches of each species, be used in a normal species by species analysis. What other methods of analysis would be appropriate?

Another approach is to examine a limited number of species as indication of the state of the whole system. The selected species might be the most important in the landings, though it might be better to select them on their biological characteristics, e.g., one or more each of long-lived and short-lived species.

3. INTERACTION BETWEEN SPECIES

The North Sea has a long history of a number of separate fisheries directed to different species of fish. This history, and especially the events of the last couple of decades when the interactions between fisheries became more apparent, was reviewed at the ICES Symposium at Aarhus in July 1975. It is perhaps not unfair to the ICES scientists to conclude from the discussions that while there are strong indications that the fishery-induced reduction of the herring, (and later the mackerel) stocks has been associated with the increase in some demersal stocks, including plaice, haddock, cod and Norway pout, the mechanics of such association are far from clear. One model was presented, which suggested that the link was due to increased food supply to the younger demersal fish, but since herring eat fish larvae the link could be direct predation on the early stages.

In view of the large number of alternative mechanisms, and the small number of observations (e.g., one estimate of year-class strength for each of a short number of years) it is difficult to determine which mechanism, if any, is the effective one purely by looking at the observed changes. Two approaches seem to offer opportunities. First, simulation models could be constructed to examine the short- and long-term history of the stocks under different assumptions concerning the mechanisms involved. This could show which mechanisms could account for the short-term changes, and also lead to stable, or quasi-stable situations, in particular the state of the North Sea stocks (including the balance between species) as they probably were early in the nineteenth century. The second approach would be to identify specific field or laboratory observations that could support, or reject, particular mechanisms. For example some clarification of the effect of predation of herring and mackerel on larval fishes might be obtained by detailed examination of the distribution of the two groups in space and time, or of the stomach contents of herring and mackerel.

In the North Sea the interactions appear to be favourable to the fishermen, that is the catches of the demersal species have, it appears, been increased by the interactions. No serious damage would have been done by ignoring these interactions, or by failing to understand them sufficiently well to make a quantitative assessment of their effects. Management policies - optimum mesh size, or fishing mortality - based on single-species analyses would seem generally to be equally applicable when the inter-species effects are considered, though the figures of total allowable catch for the demersal species would need to be increased to take account of the larger year-classes though this should be done in any case in good single-species treatment.

There seems no reason why this should be a general rule. It is quite possible that certain interactions should cause a fishery on one species to have significant adverse effects on another species, and for these to invalidate the assessment and management of the fishery on the latter species. One example of this might be fishing on a prey species reducing the food supply and hence growth of, and catches from, a predator species.

In the long run quantitative evaluation of the interactions between fisheries or between

fish stocks will presumably require a careful study of each specific case. This will often however be difficult and time-consuming, and in the short run it would seem most helpful if some general patterns could be identified. For example, it was suggested by some scientists at the ICES Symposium that the proportion of primary production converted into fish remained approximately constant, so that the reduction of one species (e.g., herring or mackerel) would almost inevitably result in the increase of another (e.g., Norway pout). Others at the same Symposium suggested that this need not be so, and that proportions going to non-harvestable blind alleys, e.g., starfish or Sagitta, might well increase, and that the efficiency of conversion from primary production to harvestable fish could be different (e.g., even if the same amount of primary production goes into herring or Norway pout, the weight of Norway pout that can be harvested may be different from that of herring).

A good example of the succession of species that can occur is the Great Lakes of North America, in which following various types of disturbances (heavy fishing of preferred species, introduction of new species - lamprey and alewife, and pollution) there have been very great changes in species composition, but not such large changes in total catches.

The other type of interaction between fisheries on different species in the same area is that of by-catch i.e., one species caught by a fishery diverted primarily toward another. This problem is generally dealt with by a set of single-species analyses. The biological problems are not, in principle, large, but the model of how the fisheries operate may need to be developed along the lines of the multi-stock models discussed in the following section.

4. FISHERIES IN DIFFERENT AREAS

A feature of many of the long-range fisheries is their high degree of mobility. Initially this tended to be a progression from one stock as it becomes heavily fished to another previously lightly or unexploited. This progress can only continue while there remain unexploited stocks, and is coming to an end. The mobility is now increasingly apparent as a switching between different stocks, all moderately or heavily exploited according to fluctuations in these stocks, e.g., in year-class strength.

This mobility causes great variations in the fishing effort in different years. If the mortality rates in each year can be accurately measured, this can help separate fishing and natural mortality and hence make stock assessment easier. On the other hand - if for example age data are missing - and other methods of stock evaluation have to be used, their application can be difficult. For example, since fishing effort is not an independent variable but tends to increase when stock abundance is high, the correlation between effort and cpue (e.g., using the Schaefer model) may well be positive, and in any case is unlikely to provide an accurate measure of the effect of fishing on the stocks. These problems, however, are those of single-species analysis and need not be discussed further here.

The other problem raised by mobile fisheries is that of developing suitable models, especially as a basis of management advice. At present the models generally used (whether of the Schaefer or Ricker/Beverton and Holt type) describe steady state evaluation in which fishing is held at a constant level. Management, as described by these models, is a matter of choosing and implementing the constant pattern of fishing that is most appropriate in view of biological, economic or social objectives. New models are being developed (e.g., of the North Atlantic cod fisheries at Lowestoft) and are producing interesting and perhaps surprising results - for example, that if year-class strengths vary greatly, mobile or versatile fisheries are not only economically attractive, but will also, if properly managed, actually produce a greater yield than constant fishing (presumably because the mobile fisheries can concentrate on a large year-class just at the time when its biomass is greatest). The general question is the degree to which such models are of wide applicability and whether there are any particular problems that need to be resolved before, for example, the North Atlantic cod model can be applied to the tuna fisheries of tropical oceans.

Another question raised by these mobile fisheries which is of significance outside narrow biological aspects, is the degree to which biologists, in their capacity of advisers to

administrators and the fisheries generally, should be greatly concerned about the fate of fisheries in particular species (provided the risk of extinction is avoided), rather than the best use of each sea area as a whole.

5. GENERAL CONSIDERATIONS

The preceding sections have frequently touched on the desirability to consider the individual species within the whole ecosystem. This parallels the concern felt by many people for the well-being and conservation of the natural environment. Though this has mostly been expressed in relation to terrestrial systems, some concern for the marine environment, with perhaps special attention given to the Antarctic (particularly in relation to whales), has also been raised. The questions that need attention include the degree to which some or all marine ecosystems, and whether, with the present capabilities to make quantitative studies of the ecosystem as a whole, such studies can provide better assessments and management or development advice than single-species analyses (possibly modified to take account of some of the more obvious interactions).

Stability has been widely discussed by ecologists. A distinction can be made between constancy (i.e., a tendency not to depart much from some fixed situation even under the influence of moderate external factors) and resilience (i.e., the ability to return to the initial conditions, even when disturbed very much from these conditions). It is clear (e.g., from the Scandinavian herring periods and the Californian scale deposits) that some, if not most, marine ecosystems are not constant but vary considerably, either randomly or fluctuating with periods ranging from years up to centuries. On the other hand, they also appear to be highly resilient as shown e.g., by the ability of North Sea demersal stocks to withstand nearly a century of heavy fishing, and for some pelagic stocks such as Japanese sardine, to recover after a period at a very low level. The question then is whether it can be safely assumed that marine ecosystems are not, so far as the effects of fishing are concerned, fragile, and that therefore concern for the ecosystem as a whole need not receive too great attention.

On the other question on the degree to which analyses of the ecosystem as a whole can be a substitute for stock assessment of the more traditional type, it may be suggested that at present the wider approach is not yet sufficiently advanced to do this. For example, more than one estimate has been made of the potential harvest of Peruvian anchovy based on the size of upwelling area, the primary production per unit area, the number of steps between plants and anchovy, and the efficiency of transfer at each stage. These estimates agree quite well with the actual catches but differ so much between themselves as to the figures used at each step to cast considerable doubt on their general reliability. While quantitative studies of the whole process from primary production to fish are of considerable scientific interest and of long-term promise, for the present, more emphasis should be paid to more conventional stock assessment.

6. MATTERS FOR DISCUSSION

In this paper a number of questions have been raised either explicitly or as assertions that could be challenged, refuted or accepted. For convenience of discussion these may be summarized as follows:

(i) To what extent and under what conditions can catch and effort data from a multi-species community be analysed as though they referred to a stock of a single-species, and give reliable results?

(ii) If the above procedure can be misleading, what additional studies could make the conclusions more reliable?

(iii) Will depletion of one species lead to an increasing proportion of the primary production becoming directly or indirectly, through secondary or tertiary production, available to other species, and if so, will these changes tend to maintain the potential fish harvest at the same level?

(iv) What models are available, or need to be developed, for making assessment of and providing management advice on mobile and variable fisheries on a number of independent stocks?

(v) To what extent does a broad "ecosystem" approach to assessment give more reliable results than a species by species approach?

(vi) Should particular attention be given to the fragility of some marine ecosystems and the risk of irreversible changes and, if so, which ecosystems?

AID IN RESEARCH PROJECTS

by

G.L. Kesteven
FAO Fishery Research and Development Project
Lima, Peru

CONTENTS

		Page
1.	INTRODUCTION	112
2.	THE PERUVIAN PROJECTS	113
3.	THE PRINCIPLES OF ANALYSIS	115
	3.1 National Institute and Visiting Scientist	117
	3.2 The Principles	120
4.	POLICY AND STRATEGY OF AID IN THE PERUVIAN PROJECT	121
	APPENDIX 1	124
	APPENDIX 2A - Establishment of a Marine Resources Institute SF:66/PER/2 - Project Description	126
	APPENDIX 2B - Fisheries Research and Development PER/66/527 - Purpose and Description	127
	APPENDIX 2C - Fisheries Research and Development PER/72/008/A/01/12	128

1. INTRODUCTION

Considering that technical assistance activities constitute an extremely large proportion of the total FAO effort in the field of fisheries, and that much of this effort is concerned with research, it is natural that the organization's advisory body on marine resources research should wish to review those activities and to assess their significance as a factor influencing the scope and efficiency of marine resources research across the world.

In his letter proposing the preparation of the present document, the chairman of ACMRR wrote "I take it that the overall aim has consistently been that of supporting the creation and establishment of, as far as possible self contained systems for conducting research and providing scientific and technical advice for the development and management of the fisheries", and he went on to indicate that he was hoping to have an analysis of the policy to which the organization work was oriented and of the strategy by which it was executed, considering in particular "(1): Training of personnel (by fellowships and on the spot.) (2): Provision of experts to establish, assist and guide the research activities and advisory functions, and (3): Supply of equipment." He proposed that the experience of the Peru projects should be taken as study material, in the expectation that a review of what has been done and accomplished in this programme, which is the longest lived and most sustained of such assistance, would indicate some of the principles according to which a larger study, of many more projects, could be carried out.

A first reconnaissance of the field of this assignment indicated at least three levels of analysis. At the first level, and very superficially, a table could be prepared showing the contributions of the UNDP programme to the fisheries work of Peru in terms of funds, man-months of experts and consultants, number of fellowships of various kinds and total man-months of these fellowships, and equipment. This table could be supplemented by corresponding statistics with respect to the counterpart component of the work. Tables of this kind are given in Appendix 1, but, for reasons exposed later in this note (p.121), the data of these tables cannot lead to the kind of assessment the chairman had in mind. At a second level a closer look could be taken at some indices of the effectiveness of particular components of the UNDP contribution and in particular, as suggested by the chairman, at matters such as "duration of assignment, contract problems (importance of language, motivation, social adjustments), the Anchoveta Panel, junior experts, consultants, FAO HQ staff etc."

However, correspondence and conversation with the chairman convinced the author of this note that, for the purposes of the ACMRR discussion, the study should accomplish a deeper analysis, reaching the philosophic and socio-economic substance of the cultural effect of the UNDP participation. Essentially the significance of this view is that an attempt should be made to determine the type and to assess the degree of change in Peruvian fishery research capacity which could be thought to have resulted from the UNDP contribution; or, conversely, to show that without such assistance the changes observed would not in fact have taken place or, if they would have taken place, would not have occurred at the time they did take place.

Obviously this is not a simple matter: it has first to be shown that changes had taken place, and if this is found to be the case, an attempt must be made to show that some of the changes took place in degree or manner in consequence of the UNDP contribution; and, after that, criteria must be applied to assess whether the changes that had taken place, and the orientation given them by the UNDP contribution, were those that should have taken place. The last point entails an obligation to present a consistent concept of the course of development of research capacity concordant with aspirations of intellectual and cultural independence.

This note reports an attempt at such an analysis with respect to the Peruvian case. In the course of this study a search has been made for principles according to which a larger study might be made on behalf of ACMRR. A brief account is given of the history of the

Peruvian collaboration in order to establish a background of main facts. A study has been made of principles with respect to development of research capacity and to the part to be played in that development by international exchange. This then is followed by a section dealing with the policy and strategy of aid in the Peruvian project in particular.

2. THE PERUVIAN PROJECTS

On a superficial view Peruvian fisheries research would seem to be concerned solely with anchovy and to take place only in IMARPE. Neither of these appearances is correct, even if the main responsibility of IMARPE is its research on anchovy and the main fishery research of Peru takes place in this Institute. The concentration on anchovy is entirely reasonable considering the great size of the anchovy resource and the economic and other significance of the fishery; and since the industry is nationalised, it is reasonable that research on this resource should be concentrated in the principal government fisheries research institute. Nevertheless, Peru has very considerable other fisheries resources, both in the sea and in its inland waters, and the exploitation of these resources requires effective research and the rational application of research results. The urgency and magnitude of the anchovy problems have inevitably pushed other research into the background, but the anchovy programme is now reaching a stage where it can be conducted in a manner to leave opportunity for wider and more extensive work on other resources. The government is anxious to have international assistance in the further development of research capacity and the conduct of the necessary research.

IMARPE was formally established on July 1, 1964 as the convergence of several distinct activities. The Peruvian Current had been an object of interest for scientists from all over the world for very many years. The Compañia Administradora del Guano had been engaged in oceanographic, biological and ornithological work for very many years. In 1954 a Concejo de Investigaciones Hidrobiológicas was established by agreement between the Navy, the Guano Company and the Directorate of Fisheries. In 1958, FAO began furnishing assistance to Peru, initially in connection with whales but subsequently in 1959 it extended its interest and in 1960 signed an agreement for a project for establishment of an Institute for research on Peruvian marine resources.

The original FAO project, relating to the formation of a fisheries research institute, Peru 002, operated from 1960 until 1964, and then was extended for two years with the provision of four experts in an advisory capacity; at the end of that period the national staff assumed complete responsibility for the activities of the Institute. However, the Government sought further assistance from FAO and this was provided in a second Project, Peru 27, which functioned from July 1967 until the end of 1971. The activities in the two projects are reported in FAO documents, FAO/SF:66/PER/2 and FI:DP/PER/66-527. A third project was then negotiated and began in July 1972.

These projects have contributed a total of approximately 2 million dollars of UNDP money in the cost of experts, fellowships, and equipment, with more than 60 man-years of experts, and fellowships to more than 28 Peruvians. The foreign staff gave the Peruvian staff training in the basic techniques of surveying fishery resources. With this assistance the Institute grew from a small nucleus of local staff, few of whom had had extensive experience, to the present Institute with approximately 262 people, of whom 112 are scientists. The present staff of the Institute carries out complicated survey operations (the like of which is not to be found elsewhere in the world); they carry out routine observations in the field, in processing plants, and in the laboratory, in biology, oceanography and technology, with a high degree of reliability.

The anchoveta fishery began in about 1954 and grew at a phenomenal rate so that by the early 1960's it became the largest single-species fishery in the world, and the Peruvian fish catch was greater than that of any other country. There was a rapid increase in the

fleet and in the shore plants and in the early 1960's the fishery began to become over-capitalized. During the 1960's IMARPE, passing through its developmental stages, was engaged chiefly in laying down the foundations of an understanding of the resources, principally of the anchovy. In those years it seemed that the anchovy catch would continue for ever to be something more than 7 million tons per year. Toward the end of the 1960's the over-capitalization and the intense rates of fishing gave rise to misgivings which were fully vindicated when the "El Niño" came in 1972 and the stock slumped badly so that in 1973 the catch was only of little more than 2 million tons.

This course of events meant that just when the IMARPE staff were gaining confidence in their work they were presented with a crisis and since then have been very heavily loaded with emergency work, attempting to find immediate answers about the state of the stock and the quantity of catch that can be taken. Since 1968 they carried out with considerable efficiency about 20 massive multi-ship operations, the greatest of which involved 81 ships. In addition to demanding the physical participation of practically the entire staff in the field work of these operations, this crisis has obliged the staff to devote considerable time to routine processing of data resulting from these operations and from the fishery itself and the staff has been left with little time to continue individual scientific development. In addition, the situation has been aggravated by inadequate technical facilities.

Thus, the first two projects established the Institute, by training the staff, designing programmes, putting various routine procedures into operation, and providing essential equipment. However, advance into a new phase of work was frustrated by the exigencies of the crisis just referred to and by inadequacy of contact with centres at which new thinking was taking place. There was little drive to modify the established programmes, and any such impulses were stifled by immediate urgencies.

The present project was undertaken for the purpose of assisting IMARPE to escape from this cul de sac. Its objectives are to assist in the development of technical services, to train the staff, to assist them in raising the efficiency of their monitoring operations and to guide them into a new stage of research in which they will undertake original studies aimed at increasing the efficiency and enlarging the scope of their models.

The activities through which these objectives were to be achieved, are described in the Project Plan of Operations. The effect of the contributions of this project has been a substantial reorientation of research and the development of systems for its effective planning and management.

A major change in project strategy was made early in 1973 when arrangements were made to secure systematic participation by staff of the Marine Laboratory, Aberdeen in different aspects of the IMARPE Programme. The principles according to which this arrangement has been developed are set out in ACMRR Working Paper 5. Under this arrangement IMARPE now has the benefit not only of the contribution of each expert during his assignment, but of his continuing advice and assistance through correspondence, and further direct collaboration with counterparts travelling to Aberdeen on fellowships; in this connection the U.K. Technical Assistance Programme has offered up to 10 short-term scholarships (minimum of 3 months) to assist in this travel of IMARPE staff to Aberdeen.

The scope of the present collaboration is being importantly expanded by the establishment of the Latin-American Regional Centre for Acoustic Research (FAO/NORAD) which is being incorporated into IMARPE and will impart instruction in acoustics research through on-the-job training. It is being further expanded through collaboration with the Coastal Upwelling Ecosystem Analysis project (CUEA) under the IDOE, in which some 10 U.S.A. universities and institutes are participating. Its work will be further expanded by its participation in the Regional Project for Study of "El Niño" (ERFEN). Finally, the Institute is receiving bilateral aid from Holland and is to receive aid from other countries, including Poland, Russia and Germany.

The developments accomplished in the past 18 months mean that by the end of this year IMARPE will be fully capable of maintaining efficiently and of steadily developing its

monitoring programme on anchovy. However, it now needs assistance in the full development of its research on other pelagic fishes and on the demersal fishes, and in particular it needs assistance in developing a full scale programme of research on inland waters resources. These developments require not only particular specialised contributions from short term consultants under the sister-institution arrangement, but also, at the higher levels, leadership in planning and directing research.

3. THE PRINCIPLES OF ANALYSIS

The analysis proposed by the Chairman is somewhat complex. It must examine the history of a particular institute in respect of development of its structure and training of its personnel; at the same time, it must seek to evaluate the progress achieved in accomplishment of research. This examination must take account, on the one hand, of the local circumstances under which the institute had been formed and operated, and, on the other hand, of the state of the science on which the institute is engaged. At the same time, and in parallel, an examination must be made of the contributions of technical assistance, of which each component has then to be evaluated.

The first part of this examination is a review of the institute per se; it is a study of the institute's present state and of historical record seeking an understanding of the present state and of alternative characteristics that might have appeared; it is a study such as might be made of any institute. But then, in the second phase, relating to the international contribution, the task is, on the one hand to attempt to assess the degree to which the international contribution has influenced the pace and direction of development of the institute and simultaneously to evaluate the different components of aid in order to assess the relative efficiency of each of them in contributing to the operational objectives of aid.

The informational basis of this study can be schematized under the following headings:

(1) Condition of the industry

(2) The state of fisheries administration

(3) The state of fishery research, locally
    at level of institute
    at level of individual

(4) Current state of the science itself

(5) Prevailing theory and practices of aid

(6) The particular aid given in the project under review

In the following paragraphs we examine each of these items in more detail.

(1) Condition of industry: Information must be obtained on the technical state and degree of development of the industry for which the research was to be carried out. This will lead to identification of the research information required for the conduct for the industry, to assessment of the industry's awareness of its needs for this information, and of the collaboration which the industry is able and willing to give to the institution. In particular the last item signifies the ability and willingness of the industry to furnish inventorial and operational (catch and effort) statistics.

(2) State of fisheries administration: Here we are concerned with the state of fisheries administration within the country's general administration, with the formulation of policy (particularly with respect to the part tc be played by scientific research), and

the nature of the organization for execution of administrative decision. This information will lead to an assessment of the official administrative units to the formulation of research plans in conformity with national socio-economic objectives, the support given to the research organization by the ministry, the attention paid by administration to advice given by the research organization, and the use made of research results.

(3) State of research: In this connection we take the following propositions as the basic frame of reference:-

The quality of the work carried out in a scientific research institute depends on the one hand on the professional competence of the research staff, and on the other hand, on certain characteristics of the institute itself.

The nature of research activity and the strength of the drive to obtain meaningful results is very considerably influenced by the following institutional aspects:

The economic conditions and career prospects that can be offered,

The professional independence permitted to research staff, and the degree of initiative they can exercise,

The administrative context in which the work must be carried out and the efficiency of the logistic support to this work,

The scientific climate of the work, both as to the exercise of criticism and the encouragement of inter-disciplinary exchange,

The cultural setting, and the awareness of the institution's mission.

The quality of individual research contributions is a function of the professional standing of the staff with respect to the following:

Basic education,

General education in science,

Fundamental methodic background:
- general principles of logic
- linguistics
- scientific method and history of science
- statistical practice and mathematics
- design of experiments and model making

Specialist training, and command of the current paradigm of his field of work,

The energy with which, through reading of current literature, awareness of recent technical and conceptual innovations is maintained,

Social orientation and awareness of the institution's mission.

Characteristics such as the foregoing are determinative of the efficiency with which a research programme is designed and executed.

(4) State of science: An institute in process of being created is bound to develop its programme with a set of methods and practices in conformity with the current paradigm of its science; its achievements in that stage must be judged with reference to that paradigm. Once an institute is established, however, and provided it has acquired genuine intellectual and culture independence, its performance ought to be judged with reference to its willingness and ability to innovate and to challenge the current paradigm. This principle should be observed in examining the record of the institute with regard to its planning and execution of its programme.

(5) Prevailing theory and practices of aid: The position in respect of this aspect is similar to that discussed above with regard to state of the science. That is to say,

the record of the aid given and the evaluation of each effect should be made with due regard for the theories currently held and the practices currently employed in giving aid; this has reference at governmental level to policy and practices in requesting international aid, and at the level of international programmes to the policies and practices adopted in choosing aid opportunities and allocating funds to them, and to the practices adopted in execution of the projects.

(6) The aid itself: Initially the examination will deal with statistics such as those given in the Table of Annex 1, but then it must proceed to evaluation and in general this is likely to be qualitative.

3.1 National Institute and Visiting Scientist

A research activity cannot well be audited in the same manner as that in which industrial activities can be audited. The construction of a building can be programmed, and the rate of output of a plant can be set and controlled, but a research director cannot dictate the time by which discoveries will be made. Even if he decides to invest a considerable proportion of his research resources in the investigation of some particular problem, hoping to reach a solution of the problem quickly, a director cannot specify the time by which that solution will be found. The methods of critical path analysis cannot help for this kind of work; they can be useful for control of a fixed set of observational practices applied in monitoring a particular system, but since monitoring is in accordance with a model developed from the results of original research of the objective system, the application of critical path methods could be helpful only in developed situations.

A research team hopes to be able to announce "discoveries" and notable advances, but such events cannot be programmed. Therefore the work of a research team cannot be audited to good effect by comparing the rate of appearance of such announcements with some schedule of expectation of them: the work has instead to be judged by the criteria of excellence of science, each piece of work judged as to its scientific merit. Equally irrelevant to this purpose are the strictly administrative records (with respect for example, to the purchase of equipment) for these can be seriously misleading - a moribund institution can be very successful in spending money.

Still further differences present themselves in the case of an institution of applied research where to the characteristics of original research are added the special features of monitoring and technological innovation, and for these still other criteria of work quality are to be applied. In the case of monitoring the criteria relate to the detail and accuracy of measurement and to the reliability of forecasts; such work has a time-relevance or is a nothing, but this does not correspond in any sense to the sequential accomplishment of a programmed set of stages. In technological innovation the criteria relate to the skill of adoptation, a quality whose exercise cannot well be programmed.

If then a research activity is to be administered, and hence reported upon, differently from industrial activity, an aid-in-research activity must differ still more. Whilst the evaluation of a research programme is made difficult by the uncertainties of discovery, evaluation of a project of aid to the planning and conduct of research is confounded by uncertainties of personality, and by others which arise from differences between the cultures and between the political and administrative systems of different countries. These uncertainties take their focus from the nature and significance of foreign participation in a national research programme, which is a matter of considerable sensitivity, because, on the one hand, of the reactions of local scientists, and on the other hand, of the attitudes of Governments of these countries to applied research.

The scientistis of a developing country are generally, and very naturally, sensitive about the presence of foreign scientists, principally because such presence may constitute a threat to them: they fear that the public generally, and the Government, may see in that presence evidence that they themselves are incompetent; they also fear that the foreign

experts will take their data to publish papers and obtain the credit which they themselves hope to gain.

The very existence of these fears in any country is itself an indicator of the underdeveloped state of science in that country. A competent research worker of established reputation does not hesitate to declare his lack of competence in fields not his own; and so it is with entire scientific communities. Practically every country has foreign scientists working in its institutions, for this is an aspect of the international, or rather non-national nature of science, and it is a sign of the maturity of a scientific community of a country that it is able to welcome the presence of foreign scientists. The United States is the largest customer for foreign talent and one of the most generous of hosts to foreign workers; its pre-eminence in this matter has its origin in several considerations, but chiefly that the presence of foreign workers is a sound investment in many ways and, as is the case of individuals, that the richer a man is the larger and more successful his investments, so it is with countries. The U.S.A. can afford to indulge itself in this matter and to carry out a greater deal of "pure" research; and it is so rich that in the field of scientific activity, the presence of foreign workers presents little threat to the job opportunities of local workers. In contrast, scientific positions are scarse in developing countries and, naturally enough, local scientists are apprehensive of anything likely to close those opportunities, and they resent being shouldered away from possibilities of making discoveries by which they might advance their career.

For their part, few Governments of developing countries are likely to offer an unreserved welcome to foreign scientists. On the one hand they are likely to take a sympathetic view of the attitude of their own scientists, perhaps only as a nationalistic reaction and with an eye to prestige, but in many cases from an understanding of the attitude taken by their scientists, and a belief in its rightness. On the other hand the immediate and ultimate objectives of research may be closely associated with matters of national policy; in which case the experts may find themselves excluded from discussions whose outcome may significantly affect the progress of research and the Government's decisions as to the what-and-why of research and the when-and-how of application of research results may leave to a foreign scientist an area of decision and independence too small for him to stand up with dignity. Yet foreign scientists must accept that the research to be carried out, its pace and direction, and the timing and manner of application of its results, are matters appertaining to the country in which they are working.

The working-face for a scientist-expert is with counterpart scientists; it is there that he has opportunity to bring about changes. If he should be brought into counsel his role is that of adviser. Being an expert in an aid-in-research project, a scientist lessens his possibility of original research and publication, first because he devotes an important proportion of his time to teaching and to logistics of research, second because he will make a gift of ideas to his counterparts, third because he works in a situation in which, by definition, the circumstances are generally not propitious for rapid progress; above all he neither appropriates data, nor makes counterparts into technicians working to provide him with material and data about which he can write. Most scientists in developed institutions work with a large measure of selfishness, jealous to secure the most funds, equipment and facilities for their own particular work; a scientist as expert must direct that sort of energy to the benefit of his counterparts and their institution.

The effect of the foregoing considerations may be summarised as follows:

> Each scientist, in his efforts to enhance his reputation and advance his career, wishes to choose those objective-systems and research methods that best suit his talent, to be able to pursue an active programme of his choosing, and to be able to demonstrate his competence by publication of scientific papers. The foreign scientists of an aid-in-research project should not stand in the way of, or frustrate these ambitions of the local scientists, but instead should assist in their realization. In consequence each visiting scientist needs to recognize that his freedom

of action as original researcher, while participating in an aid-in-research project, is likely to be in inverse proportion to the professional difference between himself and his counterparts.

In seeking the benefits that can flow from economic and social changes designed in accord with the results of research upon resources, industries and institutions, a Government must make decisions as to what research should be carried out upon what objective-system at what time and at what cost, and for what purpose. The foreign scientists of an aid-in-research project should not attempt to usurp or circumvent that function of Government, but instead should adopt the attitudes expected of advisers by the country's political ideology and its practices in public administration.

Aid-in-research projects should be formulated, carried out, reported on and evaluated with regard to:

(a) advising upon and assisting in decision processes with respect to planning and conducting research and applying its results;

(b) assisting local staff to increase their own competence and to enlarge the capability of their institutions;

(c) collaborating with local staff in the conduct of research.

For each of these activities distinctions must be made between the assistance activity as such and that which is being assisted, distinctions which at times it may be difficult to make. Thus, with respect to decision processes, advising and assisting is not the decision-process itself and hence neither decisions taken nor their consequences can tell much about a contribution made by a project; and, supposing that project contribution could be identified it still would be difficult to point to the part played by the foreign experts concerned.

Quantitative evaluation of research result is notoriously a difficult matter. This is partly because the application of results is separate from research, determined by processes which have little connection with those that direct research; and also because small research results sometimes bring large economic benefits while the contrary is also true. Probably the most realistic method is to attribute to research (from which a technological advance has followed) some proportion of the difference, in costs or earnings, between the old and the new production systems, but this methods is not always applicable. Evaluation of aid-in-research must be even more difficult, for it is a second derivative of an equation whose parameters cannot easily be measured.

A failure to make these distinctions will result in inaccurate evaluations; indeed a system which does not insist on these distinctions makes it possible to throw out a smoke screen by which to conceal the very condition that the system is intended to disclose. It is very easy to give an extended account of what is happening in an industry for which research is being carried out, but often it is the case when this is done, that the events of the industry have been in no way influenced by the research.

Next there is the problem of delimiting a project. It would seem from a typical Plan of Operations that a project is described by:

- a set of objectives
- a set of activities
- a group of foreign experts
- a counterpart group of local staff
- a set of equipment
- a supply of operating funds.

The reality, however, rarely corresponds to what is written in the Plan of Operations, since the contacts of experts are rarely limited to counterparts named with regard to a designated set of activities, and the activities cannot be carried out with only the listed counterparts, or only with listed equipment; and so on. Moreover, a "project" has no

executive administrative existence: the counterparts belong to one administrative regime, the experts to another. If a project is delimited by the Plan of Operation specification of the above items, what achievement could be attributed to it that did not also correspond to the host institution? Or, if a research result is obtained, to which of the many possible "projects" should it be attributed, and by which should it be costed?

This analysis leads to the conclusion that aid-in-research projects should be designed, organized and conducted in a manner somewhat different from that which may be appropriate for projects of other kinds.

Finally consideration must be given to the procedures of evaluation, assuming that satisfactory decisions can be taken with respect to the many aspects discussed above. It is natural that in the first place a project should be judged in terms of the degree to which the objectives described in the Plan of Operations have been accomplished but in a sense this is to beg the question since the purpose of the analysis proposed by the Chairman includes a review of the objectives chosen. It has to be accepted that in some cases the objectives set for a project are not what the Government wants or although wanted by the Government are not those that best suit its own policy; in addition the timing of efforts to achieve some objectives might be erroneous. Therefore the evaluation procedure should make use of the practices of operations research; in principle this would consist of an application of linear programming to reconstruct, with hindsight, a decision function tree which might have been prepared before the start of the project, but taking advantage of all information available as to what in fact took place during the project; this procedure would have the possibility of showing that perhaps instead of the actual result of the project, some other, preferable outcome might have been obtained.

3.2 The Principles

The main points of this section may be summarised as follows:

(1) That aid-in-research project ought to be designed, organized, and conducted differently from the design and management of other kinds of projects and therefore should be differently evaluated.

(2) That aid-in-research projects involve the following principal elements:

  (a) advising on and assisting in decision processes with respect to planning and conducting research and applying its results;

  (b) assisting local staff to increase their own competence and to enlarge the capability of their institutions;

  (c) collaborating with local staff in the conduct of research.

(3) That an expert assigned to an aid-in-research project should observe the precepts with respect to the subordination of his own professional interest and his accommodation to the administrative and other norms of institutions with which he works.

(4) That evaluation of aid-in-research project should include an examination of information under each of the headings listed on page 5.

(5) That evaluation of an aid-in-research project should distinguish clearly between the activities of the assisted institute and its staff and the activities of the foreign staff.

4. POLICY AND STRATEGY OF AID IN THE PERUVIAN PROJECT

An exhaustive study of the Peruvian projects along the lines indicated above is beyond the possibilities of the present author and in some sense, considering his current commitment with the present project, would be somewhat improper. Therefore this section merely draws attention to certain items of information and certain features of the history of these projects.

In addition to statistical information set out in Appendix 1, the objectives of the three projects are presented in Appendix 2, from the respective Plans of Operation. Reports of the first two projectsare presented in Appendix 2, from the respective Plans of Operation. Reports of the first two projects have been published as cited above on page 113; those reports carry lists of technical reports and other documents prepared in the course of each project and the second report carries references to published literature relating to the resources studied in the course of the projects.

The three projects signify three distinct stages in promotion of development of research capability in Peru. In the first stage, covered by the first project, the research institute was created and the foreign personnel were responsible for direction and administration of the entire complex. On termination of the first project, the direction and management of the Institute had been handed over completely to Peruvian personnel. The second project was more in the nature of normal aid to an established institute, involving the assignment of a relatively large number of experts and consultants, and the convening of international panels to review the work being carried out. Those panels were a very special feature of the second project. The third project, although in principle similar to the second, differed significantly, specially in its second half, because of the development of the sister-institution arrangement with the Marine Laboratory, Aberdeen.

The three phases differed also in respect of the industry condition in relation with which the research was carried out. During the first stage the industry was in full course of capitalistic expansion; the industry was entirely in the hands of private enterprise and the Sociedad Nacional de Pesca was a wealthy and influential body. Although the Institute received valuable financial support from the SNP, including eventually the gift of the research vessel, SNP-1, it had difficulties in obtaining the statistics it needed and encountered difficulties in gaining access to the catches for the purpose of sampling. Many of the characteristics of the situation persisted during the second phase but the Ministry of Fisheries was founded in 1968 and rapidly took a dominant role in management of the fishery. In the third phase, the anchovy industry was nationalized and the consequent changes in equipment and operations created a situation extremely favourable for IMARPE's work in monitoring the exploitation of the anchovy.

The reports of the first two projects are of relatively little value for the purposes of the present analysis. That of the first project covers 32 pages of which four are devoted to "objectives and implementation of the project", dealing with personnel and physical facilities and finances; the remainder of the report is a summary of information with respect to oceanography of the sea off Peru, biological investigations of the anchovy, other edible fish and guano birds, and technological studies. No analysis is offered with respect to the effectiveness of the project in respect of the three elements listed above.

The next of the second report covers 61 pages of which the greater part, some 36 pages, is devoted to the same technical material as is presented in the first report. However, this report does carry some observations on the conditions under which the foreign staff worked and points out that the foreign staff were frequently excluded from important phases of research. This report, like the previous one, makes no analysis of the effect of the foreign element, confuses the activity of local and foreign staff, and fails to identify the effects of the project. Its chapter 5 occupying three and a half pages and entitled "achievements of the project" lists a series of items, some of which are activities of

foreign experts such as advising and training, some relate to changes in methods and practices of research, and some relate to the results of research; there is however no indication of the effect of training and advising, nor of the manner in which the project contribution determined the changes in methods and practices.

There is no doubt that the foreign staff of the first project was highly successful in establishing the structure of the Institute, designing its basic programmes of research and training the local staff. This process continued in the second project but was in some measure frustrated by certain difficulties of personality and inappropriateness of some of the assignments. Nevertheless the Institute acquired an impressive capability for massive organized work; the series of multi-ship operations, generally known as Eurekas, have no parallel anywhere in the world and these are being brought to a high level of efficiency. Similarly, the Institute has carried out reliably an important series of oceanographic cruises. Its system of monitoring the anchoveta fishery probably is without equal and in the course of recent fishing seasons has presented diagnosis and prognosis apparently of quite exceptional accuracy.

However other resources have received relatively little attention and the work of the Institute has been carried out rather on an ad hoc basis; especially in recent years, with the sharp fall in total catch and the crisis atmosphere, accomplishment of work has been a feat of equilibration, moving from one emergency to another. Because of pressures, much work has been left half-done, without complete analysis of results, and of course has not been published. The Institute has a tremendous amount of unanalysed and uninterpreted data which in many cases have been made inaccessible by a sense of personal perpetry in original data. Work decisions have been highly centralized with insufficient delegation of authority and, consequently, little acceptance of responsibility for day to day decisions. High compartmentalization developed in the Institute.

The work on the anchovy, which absorbed much time and energy, was dominated during the 1960's by the MSY concept, although in fact the relevant models were not much used. The Institute's reports on the state of the stocks were subjective appraisals with reference to single characteristics, such as index of recruitment, average size of the fish, fat content, and no integration of information into a single model.

The present author does not wish at this stage to undertake an analysis of the effect on IMARPE of the work of the several panels but he must report his impression that in general the panels had depressive effect; it is his impression that the staff on the one hand felt obliged to leave to the panels the definitive and authoritative evaluation of the stock, and on the other hand, became hesitant to express independent opinion for fear of encountering contrary opinion expressed by the experts.

For the foregoing and many other reasons the staff continued almost blindly in the execution of work, applying simple techniques according to invariable patterns. Although some people showed discrimination and exercised critical faculty, they were exceptional. There was a reluctance to depart from established work patterns. This state of affairs had its origin in a number of causes, to be found in their university training, in the direction of their work, and in the intellectual climate of the Institute. The university training was, until very recently, essentially in taxonomy and descriptive biology; little preparation was given in analytic ecology, and virtually none in the application of mathematics to biology; moreover very little opportunity was given for experimental work; above all the training offered little, by precept or practice with regard to logic and scientific method.

These deficiences had then to be made good by the visiting scientists, and through fellowships and other training procedures. However it is probable that a careful analysis of the record would show that the training component of the projects was inadequate. For example, the 129 man-months of fellowships shrink in significance if it is seen as representing 1 month of advanced training per professional, or, as signifying the training of about

10% of the staff through 1-year fellowships. A more deliberate strategy would have been to arrange for a Unesco project, contemporaneously with the first of the FAO projects, to improve and supplement the university training and thus provide an in-flow of trained junior staff.

It is the present author's provisional conclusion that the aid-programme staff, presumably of FAO, misjudged the professional advance achieved by local staff during the first project, and from that basis mis-designed the second project. As he reads the evidence, the sequel was that both sides then made an erroneous estimate of the Institute's competence and inevitably came into conflict. There are all sorts of reasons why some local staff considered themselves fully competent, and no longer in need of guidance much less of direction - and therefore prepared reports without consulting the experts. Equally there are many reasons why the visiting scientists came to a contrary opinion, and resented the neglect accorded them. The clamour of the panels further confused the situation and postponed a valid appraisal of the Institute's competence.

The present author wishes to emphasize that this note is only a working paper, a preliminary sketch of a deeper study he hopes to be able to make. He therefore trusts that the opinions and provisional conclusions presented above will be discussed on this basis; that further study will lead to modification, perhaps even to rejection of them.

Totals		Project	PER/2 and Extension PER/2 (Establishment of a Marine Resources Institute		PER/27 (Fisheries Research and Development Project)		PER/008 and Enlargement PER/008 (Fisheries Research and Development Project)	
		Signature of Plan of Operations	April 21, 1960 and July 1, 1964 (Extension)		July 7, 1967		August 23, 1972 and May 22, 1974 (Enlargement)	
		Operational	June 2, 1960 and July 1, 1964		July 17, 1967		July 1, 1972 and May 22, 1974	
		Duration	4 years 1 month 2 years		4 years 6 months		3 years	
		Objective	Creation of the Marine Resources Research Institute and Advisors to the Institute (Enlargement)		Carry out a study of the anchoveta population and new resources		Train research technicians, enlarge and reorient cientific research programmes and improve the competence of the Institute. Purchasing of special equipment.	
		Counterpart	Concejo de Investigaciones Hidrobiológicas e Instituto del Mar del Perú (Ministerio de Marina)		Instituto del Mar del Perú (Ministerio de Marina)		Instituto del Mar del Perú (Ministerio de Marina)	
		Int. Meetings			3 Panels of Int. Experts		2 Panels of Int. Experts	
2 254 570	Contribution US$		948 970		US$ 852 000		US$ 453 600	
3 204 857	(UNDP/FAO)		1 660 697	(948 970 x 1.75)	1 090 560	(852 000 x 1.28)	453 600	
1 556 433	Experts		636 233	67% (399 m/m)	554 400	65% (270 m/m)	365 800	80% (139 m/m)
80 471	Fellowships 1/		42 671	5% (48 m/m)	20 000	2% (48 m/m)	17 800	4% (33 m/m)
411 768	Equipment 2/		184 768	19.5%	168 000	20%	59 000	13%
8 401	Contacts		8 401	1%				
35 547	Miscelaneous		1 147	0.1%	23 400	2.7%	11 000	3%
157 800	Agency Expenditures		72 200	7%	85 600	10%		
4 150	Direct Cost FS		3 550	0.4%	600	0.3%		
2 254 570			948 970	100%	852 000	100%	453 600	100%
			1/		1/		1/	
			Administration, Fishery Economy,		Fishery Biology, Population Dynamics		Fishery Biology	

	1/ Oceanography, Fishery Biology, Foodfish Technology		1/ Fishing and sonar techniques		1/ Oceanography, Bio-Statistics		
	2/ Equipment for a vessel ATA and fishing boat "Seiner" type, laboratory equipment, (chemical & bacteriological, Technology, Photography Laboratory, Field Laboratory, Library		2/ Expendable and non-expendable Laboratory and Technical Equipment, Workshop equipment, Fishing gear, vehicles, Publications and Final Report		2/ Computer terminal, Workshop equipment, Photo-offset equipment, Scientific ecosounder, Equipment and Projectors Laboratory accessories		
Subjects	Experts (m/m)		Experts (m/)		Experts (m/m)		Totals
Fishery Biology	139	35%	54	20%	64	46%	257 31%
Oceanography	70	17%	18	7%			88 11%
Fishery Technology	47	12%	82	30%	5	4%	134 16%
Economy	72	18%	30	11%	3	2%	105 13%
Foodfish technology	30	8%					30 4%
Naval Architecture	25	6%					25 3%
Acoustics			49	18%			49 6%
Mathematics/Bio-Statistics					24	17%	24 4%
Fishery Consultants (ad hoc)	16	4%	37	14%	43	31%	96 12%
Totals	399	100%	270	100%	139	100%	808 100%

Appendix 2A

Project of the Government of
PERU

Establishment of a Marine Resources Research Institute
SF:66/PER/2

PROJECT DESCRIPTION

This purpose will be accomplished by equipping and manning the Marine Resources Research Institute to study and keep under review the oceanographic, biological, technical, economic and institutional factors which should be taken into consideration in determining, from time to time, the intensity and manner of exploitation to which the marine resources off the coast of Peru, particularly the stocks of anchoveta, might be subjected so as to achieve this purpose; advise the Government accordingly; to engage, as part of its activities, in developing and demonstrating appropriate methods of harvesting, storing, processing, transporting and marketing marine products; and to train Peruvian nationals in the various skills required.

The Institute will investigate the existence, distribution and density of the living marine resources (studying both oceanographic and biological aspects); develop and demonstrate improved fishing techniques and fishing gear, guano harvesting methods, and practices in the storage, processing and marketing of marine products; both for export and for the domestic market; it will also investigate costs of production and marketing distribution methods and the institutional aspects of the marine products industry. In this way, the Institute will place the Government in a position where it can, by regulating the management of the exploitation of the available marine resources and by fiscal and other practical measures, ensure that economic advantage is taken of these resources.

Appendix 2B

Project of the Government of
PERU

Fisheries Research and Development
PER/66/527

PURPOSE AND DESCRIPTION

(1.1) The purpose of the project is to assist in the further development of the fishing idnstury through a study of anchovy stocks and surveys of new resources, tasks entrusted by the Government to the Instituto del Mar del Peru.

(1.2) In particular the project will:

(a) further the development of the studies aimed at providing the basis for rational exploitation of the anchoveta stocks, with a view to making recommendations to the government and/or industry regarding the measures required to ensure rational exploitation;

(b) carry out surveys of other fishery resources to determine their magnitude, biological characteristics and appropriate fishing methods, in order to assist in the development of fisheries based on these stocks, principally for human consumption and also for export;

(c) assist in the further improvement of fisheries statistics and in the studies on the economic results of the fishing activities;

(d) assist in the technical development in the fishing industry, particularly to increase the yield of fish.

Appendix 2C

Project of the Government of
PERU

Fisheries Research and Development
PER/72/008/A/01/12

A. Long-range Objectives

1. The project is intended to establish a firmer scientific base for the rational management of Peruvian fisheries and for their long term optimum utilization. This objective is in keeping with Government plans for maximizing the long term yield from fishery resources in order to: (a) alleviate the country's animal protein shortage, and (b) increase Peru's share of the world market for fishery products.

B. Immediate Objectives

2. The immediate objectives are:

(i) to improve research techniques directed toward the evaluation and monitoring of Peru's valuable fishery resources;

(ii) to expand and/or redirect specific sea research programmes pursuant to stock assessment, such as exploratory fishing (especially for consumer fish species); the application of the most modern acoustical aids for fish identification and stock size determination; and the development of appropriate fish tagging programmes;

(iii) to improve the Institute's capability for data processing and analysis through the application of the computer programmes most appropriate for bio-statistical purposes.

3. The project is research oriented and, as such, does not have an immediate, direct investment potential. However, the result of the investigations to be pursued will provide data of immense value both to the Government and private industry for planning and financing fishery development and expansion.

REVIEW OF THE PRESENT STATE OF ACTIVITIES OF THE ACMRR WORKING PARTIES AND JOINT SCOR/ACMRR WORKING GROUPS

by

E.F. Akyüz
Fishery Resources and Environment Division
Department of Fisheries
FAO, Rome, Italy

CONTENTS

		Page
1.	JOINT ACMRR/CARPAS WORKING PARTY ON SCIENTIFIC EVALUATION OF THE STATE OF THE STOCKS IN THE SOUTHWEST ATLANTIC	130
2.	ACMRR WORKING PARTY ON SCIENTIFIC ADVICE TO FISHERIES MANAGEMENT AND DEVELOPMENT BODIES	130
3.	ACMRR WORKING PARTY ON AQUACULTURE (with IABO)	131
4.	ACMRR WORKING PARTY ON FISHING EFFORT AND THE MONITORING OF FISH STOCK ABUNDANCE	131
5.	ACMRR WORKING PARTY ON MARINE MAMMALS	131
6.	ACMRR WORKING PARTY ON BIOLOGICAL EFFECTS OF POLLUTANTS (with IABO)	132
7.	ACMRR WORKING PARTY ON BIOLOGICAL ACCUMULATORS	132
8.	ACMRR WORKING PARTY ON ECOLOGICAL INDICES OF STRESS TO FISHERIES (with IABO)	133
9.	ACMRR AD HOC GROUP OF EXPERTS ON THE FACILITATION OF ACOUSTIC RESEARCH IN FISHERIES	133
10.	SCOR WORKING GROUP 32 ON BIOLOGICAL DATA INVENTORIES (with ACMRR)	133
11.	SCOR WORKING GROUP 36 ON COASTAL UPWELLING PROCESSES (with ACMRR and ACOMR)	134
12.	SCOR WORKING GROUP 45 (now known as LIAISON PANEL ON MARINE RESEARCH RELATED TO POLLUTION (with ACMRR, ACOMR, ECOR, ICES and GESAMP)	134
13.	SCOR WORKING GROUP 46 ON RIVER INPUTS TO OCEAN SYSTEMS (with ECOR, IASH, ACMRR and Unesco)	135
14.	SCOR WORKING GROUP 50 ON BIOLOGICAL EFFECTS OF OCEAN VARIABILITY (with ACMRR)	135

1. JOINT ACMRR/CARPAS WORKING PARTY ON SCIENTIFIC EVALUATION OF THE STATE OF THE STOCKS IN THE SOUTHWEST ATLANTIC

The first meeting of the Working Party, held in 1971, was reported to the 7th Session of ACMRR. A second meeting was held in Rio de Janeiro, Brazil, from 20–25 May 1974, under the chairmanship of Dr. A.E.A. de M. Vazzoler. At this meeting the first report of the Working Party was reviewed and updated on the basis of more complete and recent data on the resources in the region. A draft report was prepared on the combined results of the two meetings.

This draft report (CARPAS/6/74/4 and 4 Suppl.1) was submitted for final approval to an ad hoc meeting of the Working Party during the 6th Session of the Regional Fisheries Advisory Commission for the Southwest Atlantic (CARPAS) in Montevideo, 3–6 December 1974, and was approved with minor amendments. The CARPAS session accepted the report, although it did not include the Working Party's recommendation on the need for international cooperation in research and management (section 8(c) of the report) in its own recommendations. CARPAS noted that the report provided a useful basis for the management of the exploitation of the resources. It also recognized, however, that many estimates were still provisional and required improvement on the basis of better and more complete data. It therefore recommended that the Working Party should continue its work and should report again to the next meeting of CARPAS, and also recommended that the terms of reference of the Working Party should be expanded to include pelagic resources.

The final version of the report is in preparation for publication in the FAO Fishery Reports series.

2. ACMRR WORKING PARTY ON SCIENTIFIC ADVICE TO FISHERIES MANAGEMENT AND DEVELOPMENT BODIES

The Working Party was established in March 1971 and prepared its report (FAO Fish.Rep., (142) Suppl.1, 14 p.). The report was distributed to relevant international fishery bodies with a covering letter by the ACMRR Chairman (July 1974) which described the purpose and scope of the document.

The ACMRR 7th Session charged the Working Party to:

Establish the procedures required to ensure the efficient supply and timely application of scientific advice in an objective and usable form, keeping in mind the need for:

(i) identifying major problems of fisheries management;

(ii) examining existing methods, models and forecasting techniques used in fisheries management, so as to identify the deficiencies in these, and proposing extensions as well as new techniques and methods which will be responsive to contemporary and future changes in technology;

(iii) evaluating the impact on growth and management of fisheries of possibly changing management regimes which may result from the 1973 Conference on the Law of the Sea.

The ACMRR 7th Session also recommended that the Chairman and the officers, together with the Secretary, consider the terms of reference and reconstitute its membership as necessary. The draft agenda of the current session provides an opportunity for ACMRR itself to discuss matters relevant to (iii) above.

3. ACMRR WORKING PARTY ON AQUACULTURE (with IABO)

ACMRR 7th Session having considered the future role of the Working Party recommended its continuation with somewhat expanded terms of reference.

Since 1974 the Fishery Resources and Environment Division has been seeking United Nations Development Programme (UNDP) support toward approval of a global project on aquaculture to provide the required funding for identifying the needs of developing countries and formulating aquaculture development projects, and did not feel that the Working Party should be convened until after the UNDP support had been obtained. The global project, "Aquaculture Development and Coordination Programme", is now operational and the Working Party may resume its activities to support the Programme.

4. ACMRR WORKING PARTY ON FISHING EFFORT AND THE MONITORING OF FISH STOCK ABUNDANCE

The Working Party was established in July 1974, with the following members: Messrs. Ø. Ulltang (Norway), D.J. Garrod (U.K.), B.B. Parrish (U.K.) and L. Lee Low (Malaysia).

The terms of reference of the Working Party are:

(i) to identify, by reference to recent specific fishery situations, changes in fishing practices and techniques or in fish abundance or distribution of fish or fishing that can make the catch per unit effort a biased estimator of changes in abundance, and to propose units of effort, and additional information that can reduce this bias;

(ii) to review all methods of regularly monitoring changes in the abundance of commercial fish stocks, and in particular to compare in a general way the relative costs, precision, and risk of bias of different methods. Note should also be taken of the additional information that may be provided by the monitoring procedure, e.g. on size composition, detailed distribution, abundance of pre-recruits, etc.

The first meeting of the Working Party which was originally scheduled for September, 1975 was postponed to December because of conflict with other major events.

Due to shortage of Regular Programme operational funds, it is now proposed that the meeting be convened as part of the WAFR programme to be funded through the allocation made by UNEP to that programme.

The report of the Working Party meeting scheduled for December 1975 will be distributed to ACMRR members for information and comments.

5. ACMRR WORKING PARTY ON MARINE MAMMALS

The Working Party has been able to undertake its planned programme of work after receipt of a substantial financial contribution from the United Nations Environment Programme (UNEP) in early 1974. Four ad hoc groups of experts have been set up, to prepare material for the Working Party.

Ad hoc Group I, on large whales, has met twice, in Morges, Switzerland, 8-11 May 1974, and in Rome, 17-22 March 1975. Species reviews had been prepared in advance by its members. Most of the species of large whales have been covered. A third, final meeting of the group may still be needed in view of some issues raised at the last meeting, but these will first be discussed by correspondence.

Ad hoc Group II, on small cetaceans and sirenians, was able to make use of recent reviews of small cetaceans prepared for the International Union for Conservation of Nature and Natural Resources (IUCN) and the International Whaling Commission (IWC) as background material. It met in La Jolla, U.S.A., 16-19 December 1974. A draft report is being prepared.

Ad hoc Group III, on pinnipeds and sea otters, covers a very large number of species and stocks. Reviews on most species are being prepared by specialists in various parts of the world, and several have been completed. Due to the large amount of work involved, the group could not meet earlier, and its meeting is now scheduled for 2-6 September 1975, in Seattle, U.S.A.

Ad hoc Group IV, on general and ecological problems, had its first meeting in Cambridge, U.K., 9-11 June 1975. It reviewed the existing knowledge on the items in its terms of reference, and drew up a list of papers to be prepared for its next meeting scheduled for early December 1975, including studies on subjects such as species interactions, and case studies of marine ecosystems. The reports of groups I-III will also be included in the background material for this group.

The reports of all groups, and the relevant supporting documents, will be basic materials for a World Scientific Meeting on Marine Mammals scheduled for September 1976, and will be circulated in advance of the meeting to marine mammal scientists for comments, which will also be made available to the World Meeting. Funds for this meeting are being sought. Norway will host the meeting in Bergen, and Ad hoc Group IV is serving as the preparatory committee for it. Participation will be by invitation to individual scientists and to other international organizations concerned.

Soon after the World Scientific Meeting, the Working Party will meet to complete its final report.

6. ACMRR WORKING PARTY ON BIOLOGICAL EFFECTS OF POLLUTANTS (with IABO)

The activities of the Working Party are financed by UNEP. Established in 1974, the Working Party will review and evaluate critically the methods for bio-assays and toxicity tests presently used, in order to assess their accuracy and reliability, will select working methods to be standardized and used on selected species, and will identify research needed in this field.

The group, under the chairmanship of Dr. J.B. Sprague (Canada), and with members from France, Japan, Sweden, the U.K. and the U.S.A., works by correspondence following an outline on toxicity testing procedures drafted by the Chairman on the basis of a similar document by the European Inland Fisheries Advisory Commission (EIFAC) on fresh water organisms.

The first meeting of the group is planned for autumn 1975.

7. ACMRR WORKING PARTY ON BIOLOGICAL ACCUMULATORS

The activities of the Working Party are financed by UNEP.

Established in 1974, the Working Party will review present knowledge and evaluate and disseminate information on biological accumulators of pollutants as a basis for the development of effective monitoring programmes. Particular attention will be paid to the selection of organisms which can be used as indicators of the presence and distribution of pollutants. The Working Party will also evaluate the effects of the accumulation of pollutants in the organisms, on marine communities and on fisheries.

The Working Party, under the chairmanship of Dr. J.E. Portmann (U.K.) and with members from Canada, Japan, Mexico, Sweden, the U.K. and the U.S.A., held its first meeting in Rome from 9-12 December 1974. The report has been published as FAO Fish.Rep., (160), which includes a draft outline of a guideline manual on the use of bioaccumulators. Based on inter-sessional work, the Group drafted the manual during its second meeting in Rome, 21-25 July 1975. The final version of the manual will be prepared by the Chairman and the Secretariat later in the year.

The Working Party is expected to complete its task by December 1975 and could then be disbanded.

8. ACMRR WORKING PARTY ON ECOLOGICAL INDICES OF STRESS TO FISHERIES (with IABO)

The activities of the Working Party are financed by UNEP.

Established in 1974, the Working Party will review the available ecological indices for the purpose of measuring, surveying and monitoring the impact of pollution on aquatic communities and fisheries yields; will propose new indices for further research and testing through pilot studies; and will prepare guidelines for a well-balanced set of indices for practical use.

At the first meeting of the Working Party in Rome (4-11 December 1974) various topics considered essential to the terms of reference were discussed and working drafts of a statement prepared. In the subsequent period, leading up to a second meeting in Toronto, 30 June-7 July 1975, the results of the first session, together with other pertinent materials, were assembled into a draft report and circulated to members.

At the second and final session of the Working Party the draft report was revised in detail, resulting in an expanded report acceptable to all members. This latter document, after editing and final circulation within the Working Party, is expected to be ready for distribution in December 1975. The Working Party, which will have completed its work by the end of December, could then be disbanded.

9. ACMRR AD HOC GROUP OF EXPERTS ON THE FACILITATION OF ACOUSTIC RESEARCH IN FISHERIES

The Ad hoc Group, which was established in 1971, continued its work, by correspondence, reviewing the progress being made in the development of acoustic fish detection equipment and operational techniques and their application in fish abundance estimation studies.

The result of the survey of current research, compiled by the convener of the Ad hoc Group, Mr. B.B. Parrish, was issued in FAO Fish.Circ., (324) in March 1975 and was given a wide circulation to institutions engaged in acoustic research.

10. SCOR WORKING GROUP 32 ON BIOLOGICAL DATA INVENTORIES (with ACMRR)

Working Group 32, which was established in 1972, undertook tasks toward the revision of the Report of Observations/Samples Collected by Oceanographic Programmes (ROSCOP) form produced by the International Oceanographic Data Exchange (IODE) Task Team and developed a second-level inventory form and proposed means for its implementation. IOC-IODE accepted the form for Results of Marine Biological Investigations (ROMBI) and the Inter-governmental Oceanographic Commission (IOC) at its 8th Session adopted a resolution (VIII-21) urging member states to use ROMBI.

Working Group 32, having completed its task, was disbanded in February 1974.

11. SCOR WORKING GROUP 36 ON COASTAL UPWELLING PROCESSES (with ACMRR and ACOMR)

The Working Group was established in 1971 (Chairman, K.N. Fedorov), with Physical and Biological Panels. Close liaison was maintained with IOC, International Council for the Exploration of the Sea (ICES) and Cooperative Investigations of the Northern Part of the Eastern Central Atlantic (CINECA).

Both panels met in March 1973 and prepared their reports and made recommendations. A second meeting of the Group in Kiel, June 1974, reviewed the progress achieved and made recommendations for future activities.

Several members of the Group were represented at the El Niño Workshop (December 1974) and contributed to its work.

In December 1974 the terms of the Working Group were revised to include equatorial upwelling.

The third meeting of the Working Group is scheduled for 8–12 September 1975, when ACMRR will be represented by Dr. D. Cushing and Dr. R. Margalef.

12. SCOR WORKING GROUP 45 now known as LIAISON PANEL ON MARINE RESEARCH RELATED TO POLLUTION (with ACMRR, ACOMR, ECOR, ICES and GESAMP)

The Group correlates the activities of the subsidiary groups of the sponsoring organizations and does not itself initiate research or serve as a group of experts.

In June 1974, National Committees had been asked particularly to consider the views expressed by the Executive Committee in the Scientific Committee on Oceanic Research (SCOR) Proceedings, Vol.10 No.1 regarding the role for SCOR in marine research related to pollution and pollution monitoring programmes so that a statement could be formulated at this meeting. Some National Committees had offered comments as had some members of the Liaison Panel, all of which supported the views of the Executive Committee. In determining its policy on this matter it was necessary for SCOR to take into account the activities of many other international organizations. In doing so SCOR decided that there was no further purpose to be served by the Liaison Panel (originially Working Group 45) and agreed to recommend to the other participating organizations that it be disbanded.

SCOR's opinion on its role in marine research related to pollution can be summarized as follows:

The Thirteenth General Meeting of SCOR supported the points of view developed by the Executive Committee at its meeting in January 1974 and recorded in SCOR Proceedings Vol.10 No.1.

As a non-governmental organization, SCOR is desirous not to duplicate activities which are more appropriately under consideration by intergovernmental organizations and intends to limit its activities to those fields for which it has unique access to the necessary expertise.

In the field of marine research related to pollution, SCOR should concentrate on furthering basic studies of water movements, geochemistry and marine ecology, and advancing understanding of the boundary processes where the ocean interacts with the land, rivers, the atmosphere and the sea floor. These areas of interaction are the principle transport pathways of pollutants to the ocean. Improved knowledge of the basic processes is essential for understanding the transport of any substance, its fate in the sea and impact on resources and human activity.

The IOC International Coordination Group for Global Investigation of Pollution in the Marine Environment (IOC ICG-GIPME) has now produced a proposed outline of a comprehensive plan. This outline suggests that IOC ICG-GIPME be concerned primarily with regional baseline studies, mass balance calculations and periodic assessment of the health of the ocean which will include studying distribution of pollutants and the biological effects. The IOC ICG-GIPME will collaborate with other organizations, such as ICES, on regional activities.

The IOC ICG-GIPME maintains liaison with the relevant branches of intergovernmental organizations (such as UN, Unesco, UNEP, FAO, WMO, WHO, IAEA, IMCO, ICES) with responsibilities in relation to monitoring of pollutants in the marine environment and which are the competent organizations to consider the implementation of rational programmes which might be recommended by IOC ICG-GIPME. SCOR is not concerned with plans for routine monitoring, and therefore does not need to maintain direct relationship, on pollution matters, with these organizations provided SCOR continues to be represented at meetings of IOC ICG-GIPME.

The GIPME plan will, from time to time, identify basic scientific problems of the kind appropriate for SCOR to consider and these, together with specific research problems believed to be important by SCOR, are the areas in which SCOR should concentrate its efforts.

In adopting the above approach, SCOR will be able to make the contribution for which it is best qualified to the global study of marine pollution and will take its appropriate place within the logical division of activity in the coherent plan envisaged by IOC ICG-GIPME. SCOR remains willing to help, and to respond to requests for advice from other international organizations, whether intergovernmental or non-governmental, wherever it is competent so to do.

ACMRR action is required in transmitting to SCOR the recommendation for disbanding the Panel.

13. SCOR WORKING GROUP 46 ON RIVER INPUTS TO OCEAN SYSTEMS (with ECOR, IASH, ACMRR and Unesco)

The Group was established in February 1974 and had its first meeting in June 1974; Dr. J.S. Alabaster represented ACMRR.

The Group is concerned with questions of how river water and its sediment load acquires its chemical qualities, transformation that occurs when a river meets the sea, and the flux of constituents to the open oceans via river systems.

The Working Group is working on proposals for acquisition of relevant data on the dissemination of natural and man-made substances in the hydrosphere, to eventually develop models capable of describing the physical, chemical and biological processes operating in the river-ocean systems and interfaces.

The Group envisages a Workshop on River Inputs to Ocean Systems which might be held in late 1975.

14. SCOR WORKING GROUP 50 ON BIOLOGICAL EFFECTS OF OCEAN VARIABILITY (with ACMRR)

The Working Group was established in 1973. ACMRR is represented by Dr. A.R. Longhurst (Chairman), Dr. D. Cushing, and Dr. O. Dragesund.

The Working Group met in conjunction with the El Niño Workshop, December 1974, and discussed preparations for a seminar of the Joint Oceanographic Assembly (JOA), 1976. The Working Group agreed that:

(i) a general conceptual review of the topic should be made;

(ii) three or four well-chosen regional review papers, e.g. the Baltic, the Atlantic, including the North Sea, the Northeast Pacific, and the Peruvian region should be prepared;

(iii) review papers on different biological scales of response should be prepared.

A full meeting of the Group is planned for September 1976 at the time of the JOA.

MR/H5621/E/12.75/1/1025